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PSYCHOLOGY

The Fundamentals of Human Adjustment

NORMAN L. MUNN

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UNDER THE EDITORSHIP OF *Leonard Carmichael*

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LABORATORY OF SENSORY PSYCHOLOGY AND PHYSIOLOGY

PSYCHOLOGY

The Fundamentals of Human Adjustment · SECOND EDITION · BY

Norman L. Munn · BOWDOIN COLLEGE

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TO MY WIFE AND SON

Anna and Henry

I AFFECTIONATELY DEDICATE

THIS BOOK

INTRODUCTION

THIS SECOND EDITION of *Psychology: The Fundamentals of Human Adjustment* is in many respects an even better book than was the first edition. This is high praise, for the initial edition of this book has been widely used not only in America but in Great Britain and other countries. The reason for this success is not far to seek. In this new edition, as in the original volume, the author gives a surprisingly complete answer, from the modern scientific psychologist's point of view, to the great question: What is man?

Today there is a growing acceptance of the importance of real general education for all students in American colleges and universities. As a result of this awareness there seems to be a proper conviction that college-trained men and women in this present age should have as accurate a knowledge as possible of the factors which underlie their own mental lives and the mental processes of those with whom they must associate in our complex society.

The idea that psychology is a fundamental college study is not new. In a number of the then small American colleges in the years immediately following our colonial period it became traditional for the president to teach a required course in what was really philosophical psychology. A review of the old books used in these courses shows that such basic psychological topics as memory, sensory perception, emotion, feeling, and action were treated at length. Today, of course, as a result of the use of the scientific method, the knowledge of these important topics and related subjects has been greatly advanced. More surely today than ever before the student who wishes to have not only a liberal but also a general education can hardly afford to omit psychology from his list of college studies.

One of the advantages of Dr. Munn's book is that it is not only an effective presentation of psychology as a fundamental part of general education, but it also provides an unusually thorough introduction for the student who expects to do further technical work in scientific psychology. Because the volume so admirably combines these two points of view it is especially valuable as a college textbook. Few students are sure when they decide to take their first course in psychology that they will elect to do the major part of their college work in this field. The present like the first edition is a book which will be equally valuable for the "one course student" who is seeking a true general education and for the man or woman who elects to take much advanced work in psychology. Certainly it is a good introduction to psychology for students who are preparing themselves for work in life which concerns other people. More and more professional schools of medicine, education, law, business administration, engineering, theology, nursing, and the other fields related to the health and social sciences give courses which are best understood by the student who has a thorough knowledge of the established facts of modern scientific psychology. Much more than may be realized by students in other special fields and particularly by students of the last generation, psychology has now come of age as an independent

discipline with its own techniques and a well-tested body of important facts about human beings and human behavior. Today it would be almost as rash to enter any field of endeavor which deals with human beings without a modern knowledge of the learning process, for example, as it would be to enter a present-day chemical industry with only a literary knowledge of alchemy.

In the development and acceptance of modern psychology, good textbooks have played an important role. Historically William James' two-volume *Principles of Psychology,* published in 1890, marked a turning point in America in books on psychology. Every few years since the publication of this great work a new general book has been needed to bring together previously unknown factual and theoretical material produced by scientific psychological research. The first edition of the present book met this need in 1946 in an outstanding way. This new edition has not departed from the basic point of view of the first edition, but it does now give a carefully analyzed presentation of the major research findings of psychology since the conclusion of the Second World War. In this new edition are also included many references to the notable psychological advances that took place during the war but which, because of their then confidential character, were not available for use in the previous edition.

Dr. Munn has thoroughly rewritten the book. He has resisted the temptation merely to add a new reference here and there to his previous manuscript. This policy required him to select from the now vast accumulation of important experimental and theoretical work in psychology only those items which seemed to him to be of outstanding and lasting significance. In the editor's opinion this task of selection and integration of new with established old material has been performed in the present edition even more effectively than was the case in its notable predecessor volume. Many newly selected references are also given to assist the student who is anxious to pursue further any topic considered in this volume.

Psychology: The Fundamentals of Human Adjustment, Second Edition, like the first edition of this book, is a serious addition to the professional literature of general scientific psychology. In this new book one of America's ablest psychologists has again demonstrated that he is not merely a research scientist. He is also a great college teacher and a true master of the difficult and subtle art of effective textbook writing.

LEONARD CARMICHAEL

Tufts College

PREFACE

My aims for this second edition, as for the first, have been to give a representative survey of modern scientific psychology, to help the student develop insight into his own psychological processes and those of others, and to suggest how psychological knowledge and procedures are applicable in the solution of personal and social problems, as well as many of those in business and industry. This presentation has been guided by the view that there are certain things which our science can contribute to a rounded education and which the informed student should know. I have tried to present this knowledge in terms meaningful and hence interesting to undergraduates.

Since the publication of the first edition, many teachers and students have offered constructive criticisms, and my own use of the book has made me aware of ways in which it could be improved. Also, recent research has thrown new light on a number of important topics, suggesting the desirability of changes in several discussions, especially those on motivation, emotion, learning, and individual differences. This revision is an effort to incorporate the improvements and to reflect recent research.

Two major changes will be noticed by those acquainted with the first edition. The wording of the definition of psychology used previously, "the science of behavior and experience," may have given the impression that a species of mind-body dualism was meant. In this edition I have tried to state the definition more explicitly. Psychology is dealt with as the science of behavior, but recognition is given to the fact that, as such, it still finds a place for operationally defined aspects of what older psychologies dealt with as conscious experience. The professional reader will observe that I have made a rigorous effort to keep the present survey of psychology within an objective frame of reference.

The second major change is the use of a larger proportion of material from research with human beings, especially with children, and a smaller proportion from animal research. Some of the earlier discussions of research with rats and other animals have been abbreviated or omitted, and human material has been added. The proportion of anatomical and physiological detail has also been reduced. This has been done by omitting certain discussion and diagrams, and by abbreviating and simplifying others. The theoretical aspects of emotion and of color vision are also given a less extensive treatment.

Within a consistently objective framework, the selection of topics is eclectic. I have not attempted to emphasize any one system of behavior to the exclusion of others, nor have I stressed systematic differences. The emphasis is put on the things about which most psychologists agree, not on disagreements. Nevertheless, at certain places, as in the discussion of learning theory, opposed

interpretations of the same facts are exhibited in a manner designed to highlight the issues and stimulate student thought. While it is recognized that learning involves perceptual as well as overt response aspects, the role of reinforcement in both types of acquisition is emphasized.

Although the general organization of the book is not changed, there are now eight instead of seven major divisions, the additional section resulting from the separation of the chapters on the learning process from those on memory and thinking. Each major division of the book is now prefaced by a discussion of relevant concepts and a preview of the following chapters, the aim being to give later discussions a more meaningful setting. Certain controversial issues, such as whether psychology needs to take cognizance of neurology and whether emotion is adequately covered by the concept of motivation, are mentioned in these divisional introductions. The chapter on common social motives has been rewritten and combined with that on personal motives to form a new chapter, "Acquired Motives," and the total number of chapters thus reduced from twenty-five to twenty-four. Much attention has been given to the illustrations, with the aim of increasing their number and, it is hoped, their quality and meaningfulness.

The *Student's Manual* which accompanied the former edition has been revised with the collaboration of Dr. E. Parker Johnson. It contains a large number of experiments, exercises, and discussion questions suitable for use in conference sections, but which may be utilized by students working on their own. This *Manual* also contains self-testing exercises, with scoring keys in the appendix. These will help students test their assimilation of what they read. Vocabulary lists, arranged to parallel the chapters of the text, as well as an expanded discussion of good study techniques should provide additional help. The *Student's Manual* will be especially useful where the course is a short one and chapters must be omitted from classroom discussion. It will enable the student who must study these chapters by himself to get increased benefit from his work.

I wish to acknowledge the contributions which many others have made to this book. First there are the contributions of the hundreds of psychologists upon whose research I have drawn. Some of them have generously provided me with special illustrations, each of which is specifically acknowledged where it appears in the book.

Several of the new drawings were made from sketches provided by Dr. E. Parker Johnson, who also read the manuscript and gave many helpful suggestions. Some of the photographs by Mr. B. S. Holden of George Peabody College for Teachers have been retained from the earlier edition and these have been supplemented with photographs made especially for this edition by Mr. Stephen E. Merrill of Brunswick. Mr. Merrill's photographs are those in Figures 243, 245, 246, 264, 266, and 290. Photographs from *Life, Look, Parents' Magazine,* the *Scientific American, Science Illustrated* and film and photograph agencies are acknowledged where used. The author and the publishers appreciate the helpful cooperation received from these journals and agencies.

Criticisms received from reviewers of the first edition, from teachers of the book, and from my students have been extremely helpful in the development of this revision. Doctor Leonard Carmichael, in his capacity as Editor of the Houghton Mifflin Psychology Series, read the manuscript of the present edition and his page by page criticisms and suggestions have been a real contribution.

Barbara Wiswall deserves much credit for her assistance. She typed the manuscript, relieved the writer of much routine office work, and also checked references and quotations. Mr. Kien-Tien Fong very kindly helped me with the Chinese material on page 244. The encouragement and help of my wife are also gratefully acknowledged.

NORMAN L. MUNN

BRUNSWICK, MAINE

TO THE STUDENT

YOUR EXPERIENCE AND BEHAVIOR have much in common with the experience and behavior of other people. Even your problems of adjustment — the frustrations to be overcome, the aspirations to be achieved, the emotions to be controlled, the personal and interpersonal conflicts to be resolved — are shared by many others. So look upon this as a book about yourself — not as a treatise on some hypothetical human being. While studying it, continually ask yourself, "How does this apply to me?" Remember, too, that the study of psychology can give you insight into the conduct of other people. It should increase your understanding of why they behave as they do and, through this understanding, improve your ability to predict, perhaps even control, their behavior. Applications of psychology in the home, in the classroom, in the professions, in business, in industry, in warfare, and in the perpetuation of peace are focused primarily on the prediction and control of human conduct.

You will observe that this book is divided into eight main divisions, each of which has a brief introduction and from two to four chapters. Be sure to read the introductions whether or not they are assigned, for these deal with concepts and definitions which are taken for granted in the chapters which follow. Each chapter has a rather lengthy summary designed to bring to a sharper focus the material considered in the body of the chapter. It may be profitable for you to read the summary before you read the chapter, then reread it after reading the chapter. This is in accordance with the principle that ideas are most readily conveyed to others when you tell them what you are going to tell them, tell them, and then tell them what you have told them.

Students are often confused by a profusion of names and dates which serve to identify the author's sources. My policy has been to mention very few names in the body of the text, and then only the names of people who are historically important or especially identified with certain theories. Following the custom in many present-day textbooks, I have placed an inconspicuous number at the end of quotations or passages dealing with specific researches. If you wish to identify the person whose contribution is involved, turn to the end of the chapter and locate the number. There you will find the author and source, perhaps also a few notes concerning the study. Unless the instructor requires it, you should make no effort to memorize the names of these authors.

All major psychological terms have been defined when first used. Thus, if you come upon a word the meaning of which is not clear, locate this word in the index and turn to the page on which it was first mentioned. There, from an actual definition and from its context, you can get its meaning. A good dictionary to aid further in the development of your psychological vocabulary is Warren's *Dictionary of Psychology*. This will be found in almost any library.

Information on how to study, brief exercises and experiments to parallel each of the chapters of the textbook, and a large number of true-false, matching, and completion questions are to be found in the *Student's Manual* designed to accompany this book. The objective self-testing exercises should help you determine, after reading each chapter, how well you have grasped its contents. An appendix of the *Manual* contains scoring keys for these exercises.

CONTENTS

PART ONE · *Scope and Methods of Psychology* 1

1. The Science of Psychology 3
2. Psychologists at Work 25

PART TWO · *The Organism: Its Growth and Psychological Significance* 41

3. The Organism Viewed Psychologically 43
4. The Growth of Behavior 75
5. Heredity, Environment, and Maturation experiments 91

PART THREE · *The Learning Process* 115

6. The Conditioned Response 117
7. Acquiring Skill 135
8. Foundations of Learning 168

PART FOUR · *Memory and Thinking* 197

9. Remembering and Forgetting 199
10. Thinking 228

PART FIVE · *Motivation of Behavior* 257

11. Physiological Drives 259
12. Acquired Motives 285
13. Frustration and Conflict 305

PART SIX · *The Nature and Significance of Emotional Life* 327

14. Emotional Behavior 329
15. Feeling and Emotion in Everyday Life 361

PART SEVEN · *Knowing Our World* 383

16. Attending 385
17. Perceiving 400
18. Vision 418
19. Hearing 447
20. Our Other Senses 470

PART EIGHT · *Individual Differences* 491

21. The Statistical Analysis of Individual Differences 493
22. Intelligence 507
23. Aptitudes 545
24. Personality 569

Appendix 607

Index of Names 611

Index of Subjects 616

Part One

Scope and Methods of Psychology

NO DEFINITION OF PSYCHOLOGY has a great deal of meaning unless it is prefaced with at least a sketch of the long path from primitive to modern concepts of the mind. One difficulty in giving a meaningful definition is that the word *psychology,* which is derived from the Greek words *psyche* (soul or mind) and *logos* (discourse), no longer implies a study of the soul, nor even of the mind. The problem of defining psychology today is also related to the fact that the scope of modern psychology is so broad that no simple definition can possibly do it justice.

So we start our survey of modern psychology with a brief historical introduction. This carries us from the primitive man's idea of mind as an invisible inner representation of man himself, through certain more sophisticated ideas of the early Greeks, to Aristotle's concept of mind as a function of the organism. We then see how modern psychology, looking upon experience and behavior as functions of the organism, lays particular emphasis on the scientific investigation of behavior — of what we do and say. During the course of this discussion we shall see that the first attempts to develop a science of psychology were influenced by the work of physicists and physiologists on sensory experience. So much so, indeed, that scientific psychology, as distinguished from "mental philosophy," was first defined as the science of conscious experience. But we shall see that this limitation of the scope of scientific psychology was short-lived. Very soon psychologists were investigating many aspects of animal and human conduct, individual and social, normal and abnormal. As a matter of fact, some questioned whether one can really have a science of something so intimate and private as conscious experience. They felt that the only scientific psychology was that confined to behavior. Then the emphasis shifted from the study of conscious experience to the study of behavior. We shall show, however, that modern scientific psychology embraces, from the standpoint of behavior, much that was formerly studied from the standpoint of conscious experience.

Today the psychologist sees his task as describing and discovering the envi-

ronmental and biological bases of human conduct. His ultimate aim is to further our understanding of ourselves and our fellows so that we can better predict and control the course of human events.

Psychology has much in common with biology (the science of life) and sociology (the science of social phenomena). It is indeed both a biological (natural) and a social science. Nevertheless, the interests of psychologists in living things and in social functions are more restricted and have a somewhat different emphasis from those of biologists and sociologists.

Topics like learning, memory, intelligence, personality, abnormal behavior, and emotion find no place in books on biology, except incidentally. Psychology's closest tie with biology comes in the fields of heredity, neurology, and the biological bases of motivation. The psychologist, as we shall see, is interested in these aspects of biology not for their own sake but for what they may contribute to an understanding of why we behave as we do. His emphasis is always on behavior.

The sociologist's emphasis is on such phenomena as social evolution, social structure, and social behavior. It is with respect to the last of these topics that sociology and psychology overlap. In our discussion of psychology and social phenomena we emphasize the fact that both sociology and psychology have an interest in the social foundations of personality and in group behavior, such as occurs in crowds. These topics are dealt with by sociologists and psychologists in books on social psychology. In general one may say that, even where their interests overlap, as in the study of social psychology, the emphasis of the psychologist is on behavior while that of the sociologist is on the underlying social conditions.

Psychology as a science is distinguished from "mental philosophy" chiefly through its use of scientific methods. The meaning of "scientific method" is pointed out in Chapter 2, which also provides an introduction to the procedures used by psychologists to solve the problems which interest them. We shall observe that scientific method in psychology is essentially like scientific method in other sciences, but that its application to certain psychological problems is beset with difficulties not experienced elsewhere. This is in large measure due to the fact that the human organism is more complex than any other phenomenon, especially when responding to the complexities and intricacies of its world. How some of these difficulties are surmounted is illustrated by reference to specific problems.

These two chapters are thus designed to convey some preliminary understanding of what psychologists study and how they proceed. The discussion of what psychologists study also serves to introduce the major fields of psychology. Among these are: individual differences, educational psychology, vocational psychology, industrial psychology, animal psychology, child psychology, abnormal psychology, clinical psychology, physiological psychology, and social psychology.

1 THE SCIENCE OF PSYCHOLOGY

Psychology and Philosophy • The Organism • Philosophy, Physiology and Physics • Psychology Becomes a Science • The Expanding Scope of Scientific Psychology: Individual differences; memory; animals enter the psychological laboratory; psychology enters the nursery • Psychology and the Human Individual: The insane; the neurotic; the feebleminded • Psychology and Social Phenomena: Influence of the social environment; group behavior • The Definition of Psychology • What Psychologists Do • General Psychology • Summary

PSYCHOLOGY, like every other science, had its remote origin in the curiosity of our primitive ancestors. Primitive man's questions about the world around him eventually gave rise to such sciences as astronomy; physics and biology. His questions about himself, and especially about his experience and behavior, led to mental philosophy and finally to the science of psychology.

If we may judge from the ideas of people who live in primitive tribes today, our remote ancestors were particularly mystified by dreams. They wondered why their sleeping life involved adventures in far-off places, the defeat of their enemies, and the pursuit and eventual capture of desirable mates. Waking experience was only less mystifying. What was it that looked out of one's eyes, heard through one's ears, and felt through one's skin? Why was a man sometimes impelled to break the taboos? What made him tremble when he wished to appear brave? And what happened when action was stilled forever? Many primitive peoples answered such questions by supposing that there is a man within man — an invisible ethereal creature who, except during dreams and death, is imprisoned within the body. This was their concept of mind. The mind was for them a ghostly image of man himself. Theirs was hardly a satisfactory answer to the problem of explaining man's experience and behavior, but it represented the beginning of such philosophical speculation about the human mind.

PSYCHOLOGY AND PHILOSOPHY

Psychology, in common with the other sciences, has had a long and intimate association with philosophy. For the Greek philosophers, psychology was the study of mind. These philosophers had a concept of mind which was less crude than that of primitive man. They saw the difficulties involved in the concept of a man within man, for he was no less a puzzle than man himself, and they sought some other explanation of experience and behavior.

Some of the earlier Greek philosophers thought of the mind as a substance like breath, air, or fire. Plato (427–347) stressed the controlling influence of ideas, which were believed by him to have an existence independent of man himself. He thought of them as residing within the body during life and leaving it at death. In effect, therefore, Plato substituted independently existing ideas for the independently existing inner man of the primitive.

Psychology took a long step toward be-

coming a science when Aristotle (384–322 B.C.) pointed out that mind is a function of the body itself. He used the eye as an illustration of this viewpoint, saying that "if the eye were an animal, vision would be its mind." In other words, mind is a function of the body very much as vision is a function of the eye. According to this view, our experience and behavior are products of bodily processes. Aristotle gave ideas a place in his psychology but they were thought to be produced by the influence of the environment on the body. He taught that environmental objects activate the sense organs, which then transmit the effects of such stimulation to the heart. Here, he believed, they leave impressions which are the sources of ideas. Combinations of ideas are produced by reasoning. Ideas gathered during one's lifetime are the source of experience and provide the control of behavior. With this concept of mind it was no longer necessary to look beyond man himself for the explanation of his experience and behavior. Attention turned, eventually, from pure speculation about the mind to the study of the human organism — that of which man's mind is a function.

1 **Aristotle**

(*From Visconti's* "Iconographie Grecque.")

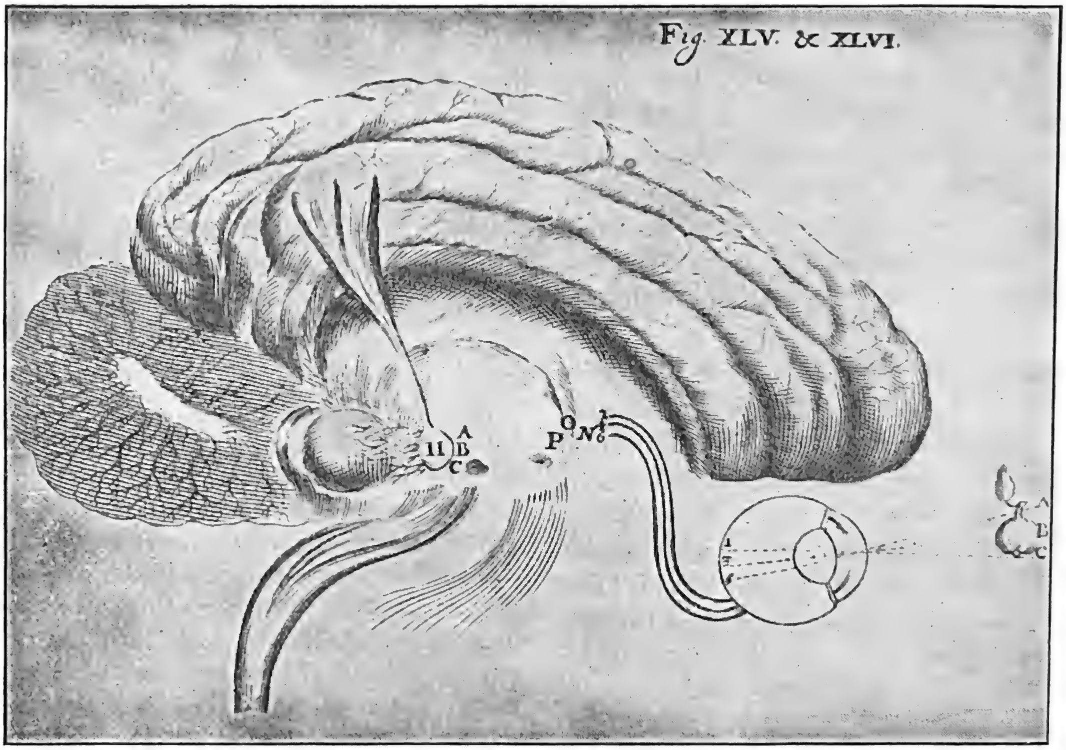
THE ORGANISM

Like his predecessors, Aristotle knew very little about the internal structure of the human organism. Dissection of the body was prohibited until about 300 B.C. It is not strange, therefore, that Aristotle, in the light of his limited information, regarded the heart as most intimately involved in behavior and experience. He believed that the brain, upon which experience is now known to depend, merely cooled the *pneuma* (blood and air) when this was heated by passion.

Our modern ideas about behavior and experience, although they owe a great deal to thinkers like Aristotle, are based upon what we have learned about the detailed physical structure of the human organism. The more men discovered about this structure, the more they were led to agree with Aristotle's view that behavior and experience are functions of the organism.

Descartes (1596–1650) thought of the organism as a complicated mechanism which may be activated by light, sound, and other stimuli without the agency of an immaterial inner substance. Animals, he said, function on a purely mechanical level. They have no soul. But man, though a mechanism and capable of behaving in as mechanical a fashion as animals, has a soul which at times directs and at times is itself influenced by the mechanism. This, of course, was a different concept of soul from that of Aristotle.

Descartes conceived of the sensory nerves, which connect the sense organs with the spinal cord and brain (Figure 2), as capable of exerting pulls upon the openings of pores in the brain. Nerves going from the brain to the muscles were thought to be tubes through which "animal spirits" flowed from the opened pores to the muscles, causing



2

A Diagram with Which Descartes Attempted to Illustrate How Light, Acting on the Eye, Influences the Rational Soul at the Pineal Gland

Compare Descartes' picture of the human brain with figures of the brain on pages 56 and 63 of this volume. Since 1662, when the above illustration was published, man has learned much about his brain. (From Descartes, R., De Homine. *Leyden: Leffen and Franciscum Moyardum, 1662, p. 100.)*

these to contract or relax. The organism was said to be capable of moving without any influence from an immaterial inner substance such as primitive man posited. In speaking of the human body, Descartes said

I desire, I say, that you shall consider that these functions in this machine naturally proceed from the mere arrangement of its organs, neither more, nor less than do the movements of a clock, or other automaton, from that of its weights and wheels; so that so far as these are concerned, it is not necessary to conceive in it any soul — whether vegetative or sensitive — or any other principle of motion, or of life, other than its blood and its spirits agitated by the heat of the fire which burns continually in its heart. . . .[1]

Although Descartes said that it is unnecessary to conceive of a soul activating the body, he claimed, as we have seen, that a soul does exist in man. He supposed that, by causing the pineal gland at the base of the brain to move this way or that, the soul may control the direction in which animal spirits flow.

Despite his inadequate concept of the structure and functions of the nervous system, Descartes was pointing the way toward the interpretation of behavior, and ultimately of experience, in terms of activities of the sense organs, nervous system, and muscles. Nevertheless, many years elapsed before this interpretation was finally established.

PHILOSOPHY, PHYSIOLOGY AND PHYSICS

For more than 200 years after Descartes, psychology remained a branch of philosophy — the branch known as mental philosophy. During this time, however, physiologists were discovering a great deal about the sense organs and nervous system. The information that they gathered not only removed much of the ignorance of organic functions which was so evident in the writings of Aristotle and Descartes, but it also laid the foundation on which a science of psychology was eventually erected. There were also relevant advances in physics. Physicists were demonstrating the nature of the environment which Aristotle and Descartes had suggested is so important in activating the organism.

Philosophy

The philosophical method of dealing with psychological problems produced many keen observations and descriptions of experience and behavior, but its chief emphasis was upon speculation concerning such interesting, yet probably unanswerable problems as "What is the ultimate nature of mind?" or "Is the world real or a product of man's imagination?" and "Does man have a free will?" Preoccupation with such questions did not greatly advance man's understanding of his experience and behavior. Little was revealed that had not already been brought out by such philosophers as Plato, Aristotle and Descartes. The fact that philosophers could not agree in their speculations about the bases of experience and behavior was not so disturbing as the fact that speculation without scientific methods of observation offered no apparent basis of agreement. The things discussed were, by their very nature, beyond range of observation. One could not observe the mind, he could not penetrate beyond the world of experience, and he could not put the will under a microscope. Indeed there was a disposition among some philosophers to disparage observation, even of the observable. They preferred to settle problems by rational argument alone. This is well brought out, doubtless not without exaggeration, in the following quotation from Francis Bacon, a leader (1605) in development of the scientific method.

> In the year of our Lord 1432, there arose a grievous quarrel among the brethren over the number of teeth in the mouth of a horse. For 13 days the disputation raged without ceasing. All the ancient books and chronicles were fetched out, and wonderful and ponderous erudition, such as was never before heard of in this region, was made manifest. At the beginning of the 14th day, a youthful friar of goodly bearing asked his learned superiors for permission to add a word, and straightway, to the wonderment of the disputants, whose deep wisdom he sore vexed, he beseeched them to unbend in a manner coarse and unheard-of, and to look in the open mouth of a horse and find answer to their questionings. At this, their dignity being grievously hurt, they waxed exceedingly wroth; and, joining in a mighty uproar, they flew upon him and smote him hip and thigh, and cast him out forthwith. For, said they, surely Satan hath tempted this bold neophyte to declare unholy and unheard-of ways of finding truth contrary to all the teachings of the fathers. After many days more of grievous strife the dove of peace sat on the assembly, and they as one man, declaring the problem to be an everlasting mystery because of a grievous dearth of historical and theological evidence thereof, so ordered the same writ down.[2]

The student of mental philosophy tended to align his thought with that of one or another of the great philosophers or to remain confused by arguments leading to no dependable answer. Like Omar Khayyám he might well have said,

> Myself when young did eagerly frequent
> Doctor and Saint, and heard great argument
> About it and about, but evermore
> Came out by the same door where in I went.

Physiology

Physiology was, by contrast, down to earth; so much so, in fact, that to some philosophers the ultimate significance of physiological investigation seemed trivial. Yet physiologists, by observing and by following similar observational procedures, found that they could come to agreement about the things studied. Here, for example, is the report of an early (1824) physiological experiment which revealed certain relations between a brain structure (the cerebellum) and behavior.*

> I made a lesion in the cerebellum of a young and healthy dog by means of incisions which extended deeper and deeper. The animal gradually lost the power of ordered and regular movement, and when the mid-region of the cerebellum was reached he could only totter along with a zigzag motion. When he tried to go forward he would go back and when he wished to turn left he would turn right. He made great efforts to move, but being unable to control them he would bound forward suddenly and fall over himself. If there was any obstacle in his way he was quite unable to avoid it, however hard he tried, and he knocked against objects on all sides although he could see and hear perfectly well; when irritated he tried to bite and indeed did bite whatever was annoying him, if he could get hold of it, which was seldom, since he could not control his movements with precision. The animal was in full possession of his intellectual facilities and his senses and there was no trace of convulsion; he was merely deprived of the power to control and regulate his movements. When I extended the lesion to the innermost layer of the cerebellum the animal lost the power of motion and of equilibrium completely.[3]

By asking specific questions and designing suitable experiments, physiologists discovered the circulation of the blood, the separate functions of sensory and motor nerves in the spinal cord, the parts of the brain which enable man to control his own movements, the speed with which a nerve impulse travels, the structures in the eye which enable us to see colors, the structures of the ear which make hearing possible, and many other facts of especial interest to anybody who wants to learn how man responds as he does. One value of observational methods, as against sheer speculation, is that anybody who is skeptical of the investigator's conclusions can repeat the observations. Thus the facts of physiology, some of which were at first in dispute, have been established by repetitions of the original observations. The hope that psychology might be put on an equally sound basis was behind the movement to take from mental philosophy as many of its problems as could be subjected to experimental investigation and attempt to build a science of them.

Physics

The experimental method in physics likewise added to psychological knowledge and at the same time hinted at the possibility that psychology might itself become a science. Physicists discovered the nature of those aspects of the environment (stimuli) which give rise to sight, hearing, and other experiences. They found, for example, that colors vary with the wave length of light, that the more rapidly a musical instrument vibrates the higher the pitch of the sound heard, and that the intensity of light and sound varies with the magnitude of the respective waves. The physicist wanted to know whether a certain color, say purple, could be synthesized from other colors, so he mixed various colors until he discovered that, by mixing red and blue lights, he could produce purple. As in the case of physiology, the skeptic could do the experiment himself.

In the last quarter of the nineteenth century, when psychology branched out as a

* Such operations would be done today under deep anesthesia, so as to remove the possibility of pain. But even in human brain operations (see p. 64) no anesthesia of the brain is used and no pain is experienced by the fully conscious patient.

field of investigation separate from philosophy, physiology, and physics, it was concerned chiefly with describing and trying to discover the bases of human experience. Since physicists had already been dealing with the stimulus aspects of experience and physiologists with the bodily bases, this early scientific psychology borrowed extensively from experiments made by physiologists and physicists.

We thus observe that, at a time when psychologists within philosophy were in a stalemate, finding no basis of agreement on the issues which concerned them, physiologists and physicists were gaining dependable information on the physiological and physical aspects of behavior and experience. This advance may be credited to the fact that they gave up mere speculation in favor of experimental investigation. Similar investigations launched psychology upon its scientific career.

3

Wilhelm Wundt

(From a bronze plaque by Dr. Felix Pfeifer, reproduced through the courtesy of Dr. Edwin G. Boring and Dr. Karl M. Dallenbach.)

PSYCHOLOGY BECOMES A SCIENCE

The formal launching of psychology as a separate science occurred in 1879 when Wilhelm Wundt opened his Psychological Institute at the University of Leipzig. Wundt was a physiologist and a philosopher who had made contributions to both of these fields. While he was an experimental psychologist he continued making important contributions to philosophy.

The new movement was not so much a revolt against mental philosophy as an attempt to get psychology out of an impasse, by utilizing methods which had proved so fruitful in the natural sciences of physiology and physics.

It should of course be recognized that no science is, in an absolute sense, independent of philosophy. Neither Wundt nor later psychologists completely broke away from philosophy. Indeed, one can assert, with some degree of assurance, that psychology and philosophy will always have a great deal in common. Scientific endeavors, psychological or otherwise, are necessarily preceded and followed by speculation. Today there is a flourishing branch of philosophy, the philosophy of science, which examines critically the aims, methods and conclusions of all sciences. Modern philosophers are often trained in the several sciences and their aim is to discern the ultimate significance of all scientific findings — to look beyond the relatively narrow confines of a particular science and get an overall view of the nature of man and the world he lives in.

The statement that psychology became a science thus means, not that it proclaimed its independence of philosophy, but that it gave up sheer speculation in favor of scientific procedure. What, however, is scientific procedure? It involves: (1) making system-

atic rather than aimless, observations, (2) being impersonal in one's search for truth, seeking information to *test* rather than to prove ideas already held, and (3) making it possible for others to repeat one's observations, under essentially the same conditions, and to confirm or modify them.

The requirements of science are most closely met when investigators use experimental methods; when, instead of observing what occurs spontaneously, they change certain aspects of nature and note the effect of these changes on phenomena which come within the range of their inquiry. Psychology most clearly achieved scientific status when it became experimental.

Wundt first applied experimental procedures to the analysis of consciousness, his aim being to discover, as it were, the ingredients of conscious experience. Indeed he defined psychology as the science of consciousness. Individual observers were trained to attend to and describe their own experiences while the experimenter made various changes in light, sound, and other external conditions. He also made changes in physiological conditions. For presentation of stimuli he utilized the apparatus and methods of the physicist. In producing physiological alterations, he used the methods of physiology. Physiological discoveries were used to interpret psychological findings, especially to relate the results of psychological experiments with functions of the nervous system.

The method of attending to and describing experiences under known external and internal conditions was called *experimental introspection.* For Wundt it was *the* method of psychology and distinguished this science from other sciences. The chief outcome of Wundt's "science of consciousness" was a detailed description of conscious experience in terms of such *elements* as sensations, images, and feelings. Consciousness was, so to speak, dissected into mental elements as matter is dissected into atoms. It has been said that Wundt's was a science of the contents of consciousness.

Soon after the formal founding of a science of psychology at Leipzig, graduate students flocked to Wundt's laboratory from all over the world. After receiving their doctorate, most of them returned to their own countries where they opened similar psychological laboratories. Today, in the United States alone, there are over 7000 trained psychologists. But very few of these are even remotely like the psychologists of Wundt's day. The transition from Wundt's science of consciousness to the much broader psychology of today is worth describing. We shall see that psychologists were not content to describe consciousness and turn their backs on more fertile fields of inquiry. As Table 1 (page 10) illustrates, psychology today is concerned more with behavior, with what organisms do, than with conscious experience. This also illustrates the many branches of current psychological activity.

THE EXPANDING SCOPE OF SCIENTIFIC PSYCHOLOGY

next

In developing from its beginnings in Wundt's laboratory, psychology went through various phases which led up to the psychology of today. An early step in this broadening of scope was the effort of certain psychologists to study the *functions* as against the *content* or *structure* of consciousness. Perhaps the most important impetus for development of a "functional" psychology came from the Darwinian doctrine of evolution.

Darwin, in discussing the struggle for existence, had pointed out that organisms which have the most adequate means of adjusting to their environment are those most likely to survive. How consciousness might aid survival of organisms possessing it appeared, therefore, worthy of scientific study. Introspection revealed that often in learning

TABLE 1. THE INTERESTS OF MODERN PSYCHOLOGISTS AS REVEALED BY THE TABLE OF CONTENTS OF *Psychological Abstracts*

General

Theory & Systems • Methods & Apparatus • New Tests • Statistics • Reference Works • Organizations • History & Biography • Professional Problems of Psychology

Physiological Psychology

Nervous System

Receptive and Perceptual Processes

Vision • Audition

Response Processes

Complex Processes and Organizations

Learning & Memory • Thinking & Imagination • Intelligence • Personality • Aesthetics

Developmental Psychology

Childhood & Adolescence • Maturity & Old Age

Social Psychology

Methods & Measurements • Cultures & Cultural Relations • Social Institutions • Language & Communication • Social Action

Clinical Psychology, Guidance, Counseling

Methodology, Techniques • Diagnosis & Evaluation • Treatment Methods • Child Guidance • Vocational Guidance

Behavior Deviations

Mental Deficiency • Behavior Problems • Speech Disorders • Crime & Delinquency • Psychoses • Psychoneuroses • Psychosomatics • Clinical Neurology • Physically Handicapped

Educational Psychology

School Learning • Interests, Attitudes & Habits • Special Education • Educational Guidance • Educational Measurement • Education Staff Personnel

Personnel Psychology

Selection & Placement • Labor-Management Relations

Industrial and Other Applications

Industry • Business & Commerce • Professions

The *Psychological Abstracts* publishes brief digests of psychological articles which appear in every country in the world. In 1950 a total of 6563 articles were abstracted, and the abstracts were classified in accordance with the table shown here. The *Abstracts* is edited by C. M. Louttit and A. J. Sprow of the University of Illinois with the co-operation of psychologists in the United States and other countries. It is published by the American Psychological Association.

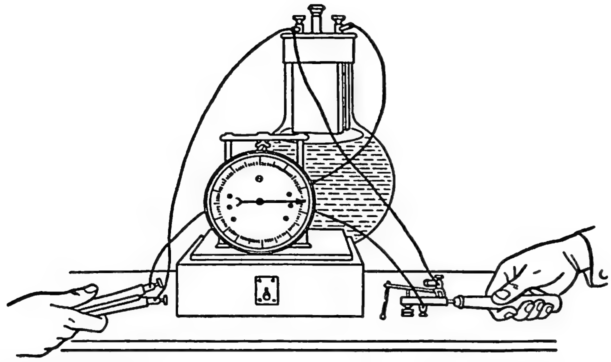
a motor skill one is at first vividly conscious of one's activities. As the habit approaches perfection, however, consciousness gradually recedes. The perfected habit then is carried out automatically, without necessary participation of consciousness. Thus it appeared that consciousness contributes to the survival of organisms by aiding them to learn.

This approach to the study of consciousness was especially emphasized at the University of Chicago around the turn of the century. James Rowland Angell, later president of Yale University, was its chief advocate. Functional psychology failed to advance an understanding of what consciousness is, or even, to any appreciable extent, of what consciousness does. Nevertheless, it proved very important in shaping the further development of psychology. Seeking to discover the functions of consciousness in adjustment, psychologists were led to investigate the learning process itself. They eventually paid attention less to consciousness and more to the environmental and organic conditions which produce efficient learning. Such a change of emphasis made what had previously been regarded as a science of the functions of consciousness a science of behavior as well. Psychology as a science of behavior, however, had still other antecedents, some of which we shall now consider.

Individual differences

Even at Leipzig, psychology was not long confined to the study of consciousness. J. McKeen Cattell, one of Wundt's American students, was interested in the nature and rapidity of reactions to various stimuli, such as colors, letters, and words. His investigations involved analysis of consciousness, yet he was most interested in what his subjects did or said. Partly as a result of stimulation received from Francis Galton, an Englishman who had previously studied the inheritance of intelligence, Cattell turned his attention to individual differences in the reactions of his subjects, including their speed of reaction, as measured by the chronoscope, one early form of which is shown in Figure 4.

This interest soon led to the direct meas-



4 An Early Form of Chronoscope for Measuring Reaction Time

This is the D'Arsonval chronoscope. The subject was seated with the response key in his hand. When the experimenter struck the top of the table (or the subject's hand) with his key, he gave the signal for response and simultaneously opened an electrical circuit which caused the chronoscope pointer to engage with a clockwork device. It then swept the dial once per second. As soon as the subject squeezed his key, a circuit connected with a magnet was closed thus disengaging pointer and clockwork. Since the experimenter's signal activated the pointer and the subject's signal stopped it, the elapsed time, read in 1/100 sec. units, gave the latter's speed of reaction. (After Binet.)

urement of individual differences by means of standardized tests. Out of such research grew the intelligence and aptitude tests which later became important in the fields of educational and vocational psychology. Moreover, statistics became a psychological tool. Statistical procedures are used to discover group trends, the magnitude and reliability of differences, and the relation between differences in one ability and differences in another.

Memory

While Wundt was developing an experimental science of conscious experience at Leipzig and an interest in individual differences and statistical analysis was developing under the influence of Galton and Cattell, a German philosopher named Hermann Ebbinghaus began the experimental investigation of memory. This was an aspect of life about which philosophers had engaged in much discussion, but which had not yet been subjected to scientific investigation.

Ebbinghaus investigated several important problems related to memory. In these investigations behavior rather than conscious experience was the prime object of attention. In other words, Ebbinghaus was interested in verbal or written reproduction of what was memorized, not in a description of sensations, ideas, or feelings. Ebbinghaus published his results, and other psychologists took up the experimental study of memory, introducing new and better techniques and attacking additional problems. Research in this field contributed valuable psychological knowledge. Since memory research was capable of answering many practical problems of education, it became an important aspect of the field of educational psychology.

Animals enter the psychological laboratory

Psychology was expanding in other directions. Interest in the doctrine of evolution led several English biologists and philosophers to turn their attention to the intelligence of animals.

Observations on animal behavior were at first quite incidental. There was usually no attempt to carry out systematic experimental studies. The method commonly in use was anecdotal. A psychologist who used this method might let it be known that he was planning a book on the evolution of intelligence and would like owners of pets or other observers of animals to report any examples of intelligence which they had noticed. As the descriptions of behavior came in from all and sundry, he would classify them, and from the accumulated evidence, such as it was, attempt to portray the evolution of in-

telligence from, say, goldfish to man. One difficulty with such information is that the unscientific observer wants to tell a good story, usually one in which the animal is assumed to have "almost human" intelligence. Illustrative of the anecdotal method is the following:

> An Australian lady, reporting on the burial of deceased comrades by soldier ants near Sydney says, "All fell into rank walking regularly and slowly two by two, until they arrived at the spot where lay the dead bodies. . . . Two of the ants advanced and took the dead body of one of their comrades; then two others, and so on until all were ready to march. First walked two ants bearing a body, then two without a burden; then two others with another dead ant, and so on, until the line was extended to about forty pairs, and the procession now moved slowly onward, followed by an irregular body of about two hundred ants. Occasionally the two laden ants stopped, and laying down the dead ant, it was taken up by the two walking unburdened behind them, and thus, by occasionally relieving each other, they arrived at a sandy spot near the sea." A separate grave was then dug for each ant. "Some six or seven of the ants had attempted to run off without performing their share of digging; these were caught and brought back, when they were at once attacked by the body of ants and killed upon the spot. A single grave was quickly dug and they were all dropped into it." No funeral procession for them.[4]

One suspects that the good lady's imagination ran away with her scientific veracity. This anecdote about ants could be matched with others concerning not only animal, but also child and adult behavior.

Science cannot advance far on the basis of such anecdotes. As we have already pointed out, it must have systematic and reliable information, and it must know the precise conditions surrounding a given event. The scientific approach is to ask specific questions and arrange conditions which will force an answer to them. Hence, animal psychologists soon discarded the anecdotal method in favor of experimental investigation. Investigators asked questions such as, "At what level of evolution does the ability to learn first appear?" They then devised problems to test the learning ability of animals at various stages of evolution.

In many such experiments, animals were deprived of food until hungry. They were then offered a chance to discover the shortest way to a source of food. The experimenter asked, "How many trials are required before the animal can go directly to food?" "How many errors are made in learning the most direct route?" "How much time is consumed in successive trials?" Animals of different species could then be compared in terms of the number of trials, errors, and time required to learn a well-defined problem. Information on vision, hearing, motivation, reasoning, and other psychological processes was gathered by similarly direct experimentation. At the beginning of this century there were already important centers for such experimentation in Russia, England, Germany, and the United States

One should not get the impression, however, that all animal psychology necessarily has evolutionary implications. We are interested in the psychology of our pets, such as dogs and cats; scientific investigation provides this information. Thus the behavior of these and other animals is often studied without any reference to the evolution of intelligence.

Physiologists and psychologists also use animals as tools. Some animals aid in the investigation of many problems which, for various considerations, cannot be solved by the direct use of human subjects.

Suppose that the psychologist wishes to discover which parts of the brain are of especial significance for given types of behavior; for example, the process of learning. If observations were restricted to human subjects, he could base his conclusions only upon occasional cases where, due to disease or accident, the nervous system was injured.

Adequate data on psychological functions both before and after onset of the disturbance would not, in most instances, be available. The location and amount of injury to the brain could not be evident to the investigator unless the individual died and his brain became available for observation.

When animals are used, however, their behavior can be tested before and again after specific brain injuries have been produced under anesthesia. Changes in behavior after the operation may then be attributed to known injuries, and the functions of the various parts of the brain may be established for animals of that species. Furthermore, to the degree to which their brain has the same basic pattern as man's, the results may be used to interpret human brain functions.

Apart from its solution of particular problems, animal psychology influenced the procedures used in research with human beings. It demonstrated that much information previously thought to require introspection could be obtained by experiments on behavior. It also affected the theoretical basis of psychology. The more we know about a process in one organism, the more it must affect our interpretation of this process in another. The relative simplicity of the animal is often a help rather than a hindrance. Medical students learn something about the structure of fish, cats, and other simpler forms before they begin to dissect human organisms. Likewise, the builder of skyscrapers begins by building simpler structures.

Psychology enters the nursery

Philosophers and educators have always speculated about the importance of child development in determining the nature of adult experience and behavior. It seems surprising, therefore, that careful investigation of child behavior has so recent an origin. Fifty years ago there was little published information on the sensitivity, learning ability, emotion, or other psychological processes of children, except that contained in a few scattered biographical accounts written by parents. Some of these accounts supply much valuable information, but most of them are full of anecdotes in which it is difficult to separate fact from fancy. The most comprehensive and thorough biographical account, written by a physiologist named Preyer, is *The Mind of the Child,* published in 1882. Preyer listed the reflexes of his child at birth, and at various age levels beyond. He also reported observations on such processes as voluntary activity, imitation, sensitivity, emotion, and reasoning. It was not until the present century, however, that systematic observations of many children, under known conditions of stimulation, were carried out. These observations were frequently experimental.

When experimental investigations with children were finally undertaken, many of the methods used were similar in principle to those developed in animal psychology. The reason for this is readily apparent. Young children, like animals, are unable to report the nature of their experiences. Only their behavior can be observed directly. Nevertheless, investigations of behavior yield valuable information concerning sensory functions, learning ability, emotion, and other psychological processes.

Investigating the psychological processes of children is important for two reasons. In the first place, it makes possible a reconstruction, as it were, of the origins and early development of adult behavior. Such reconstruction contributes to our understanding of why we act as we do. In the second place, the reliable information gained from such investigations is of practical value to parents and educators. How is one to direct the development of children intelligently, unless he knows the aspects of their surroundings to which they respond, the level of their learning ability, and the nature of their interests.

PSYCHOLOGY AND THE HUMAN INDIVIDUAL

The sphere of psychology expanded to include the study of insane, neurotic, and retarded individuals. Until such abnormalities of behavior came within its scope, psychology was concerned primarily with investigation of processes (vision, perception, learning, and so on) which are similar in all normal human beings. Emphasis was on the process itself, not on individual manifestations of it. Interest in individual differences did, as we have seen, finally develop. But even this interest was more or less abstract. The investigator wanted to know the extent and nature of individual differences. He was not especially interested in Mary Smith or Henry Jones. There was little or no investigation of personal problems with a view to diagnosing their causes and suggesting remedial treatment.

When psychologists were finally led to undertake such investigation, they developed the concept of personality, a concept which takes into consideration not only psychological processes, but also the characteristic pattern of these to be found in particular individuals. Medicine, and particularly that branch of it known as *psychiatry*, played a leading role in this broadening of psychological interests.

The insane

Until a hundred and fifty years ago insane * people were, in general, thought to be wicked, possessed of the devil. They were thrown into prison along with thieves, prostitutes, and murderers, or locked up in "lunatic" asylums. When they were not neglected, these unfortunates were beaten, purged, or bled. The aim was not so much to cure as to weaken them so that they could be handled more easily.

Physicians paid little attention to insanity, for medicine was concerned with bodily ills, not with the manifestations of demons. Psychology was still mental philosophy, hence not concerned with such problems. Into this situation came a French physician, Pinel, who is generally regarded as the father of psychiatry, a branch of medicine which studies and treats behavior disorders. It was Pinel's belief that insane people are ill rather than wicked, or controlled by supernatural forces; and that they should receive humane treatment. When he became superintendent of a "lunatic" asylum in Paris, Pinel's first act (Figure 5) was to remove the irons from his charges and to take them out of dungeons in which they had been locked for years. By treating them like human beings, he was able to restore many to sanity. But Pinel and those who followed him were scientists as well as humanitarians. They observed, described, classified, and attempted to discover the causes of behavior disorders.

Following the work of Pinel and others of his kind, physicians turned their attention increasingly to the description, classification, and study of the origins of insanity. They found, among other things, that such factors as syphilitic destruction of brain tissues, hardening of the arteries of the brain, and degeneration of the nervous system through action of drugs, account for some forms of insanity. Such insanities they classified as organic. On the other hand, certain kinds of insanity were found to occur without apparent injury to the organism. These were classified as functional, as due to abnormal functioning of a structurally intact organism.

But how could a normal structure come to function so abnormally? The answer was that the functionally insane person develops wrong ways of regarding himself and his relations with those around him; that his habits of thinking are deranged.

* Insanity is a medico-legal term, not a psychological one. Most of the legally insane are today referred to by psychiatrists and psychologists as *psychotic*.

5

Pinel Releasing the Insane from Their Shackles at La Salpêtrière Asylum in Paris

(From a copy in the Central State Hospital, Indianapolis, of a painting by Tony Robert-Fleury. Photographic reproduction, courtesy of Dr. Max A. Bahr.)

Such an emphasis on habit and thought at a time when psychologists were beginning the study of these processes in normal individuals gave psychiatry and psychology a common ground. It helped draw the attention of psychiatrists to normal psychology, and it at the same time aroused the interest of psychologists in abnormal as well as in normal behavior. The mental test movement, which was developing in psychology at the same time, contributed to this rapprochement of medicine and psychology, for tests could aid in diagnosis of abnormal as well as normal reactions. Since that time psychologists and psychiatrists have jointly contributed to our understanding of insanity.

Psychologists are interested in the insane for several reasons. In the first place, any form of behavior, normal or abnormal, comes within the legitimate scope of psychology. In the second place, if the psychologist knows what happens to a mechanism when it breaks down, and especially the causes of breakdown, he can better understand its normal functions. In the third place, if one knows what conditions produce insanity, he may be able to prevent its occurrence or even to cure it. Prevention of insanity and of the disorders which we shall discuss next is the aim of a branch of psychology and psychiatry known as *mental hygiene.*

The neurotic

Many persons who have nothing organically wrong with them suffer from psychological disorders known as *psychoneuroses.* These people may be paralyzed, may lose their memory, may take "fits," may lose sensitivity of one kind or another, may suffer

"imaginary" aches and pains, may worry constantly without adequate cause, may remain in states of indecision, may be queer, or may be morally perverse. How scientific attention was attracted to such relatively minor abnormalities is an interesting story only the barest outline of which can be given in this preliminary survey of the scope of psychology.

Hypnosis played a major part in bringing psychoneuroses to the attention of scientists. In 1766, Mesmer, a Viennese physician, reported that he could produce trances and remove some of the neurotic symptoms mentioned above by applying magnets to his patients. He believed that some force left the magnet and, by entering the body, effected a cure. Mesmer discovered later, however, that magnets were not necessary. The same effects could be produced by making motions with his hands. It then appeared to him that a force, which he called "animal magnetism," went from him to his patient.

After investigating Mesmer's claims, scientists came to the conclusion that animal magnetism did not exist, and that Mesmer was a quack. This pronouncement, while it placed Mesmer and "mesmerism" in ill repute, did not rule the phenomenon of hypnosis out of existence. Nor did it account for the cures which Mesmer had undoubtedly produced.

About a hundred years ago several English physicians revived interest in mesmerism. One of these, Braid, introduced the term "hypnosis" or "nervous sleep" as a substitute for mesmerism. The new name, Braid's prestige, and the fact that the phenomenon was attributed to brain fatigue rather than to something mysterious, gained hypnosis a certain amount of medical recognition. For a time it was used to produce anesthesia during operations. In India a surgeon performed hundreds of painless operations, including amputation of limbs, while his patients were hypnotized. After chloroform and ether came into use, however, hypnosis was seldom used as an anesthetic.

A famous French physician named Charcot read of Braid's work with hypnosis and was impressed by the fact that hypnotized persons exhibit symptoms essentially like those found in the form of psychoneurosis known as *hysteria*. At the suggestion of the hypnotist, for example, a person may become blind, lose the use of his limbs, forget his name, or have convulsions. Because of these facts, Charcot was convinced that hypnosis is a form of hysteria. This view failed to receive general acceptance. Many psychiatrists, while admitting the value of hypnosis in treatment of hysteria, neither regarded it as a form of hysteria, nor as essentially abnormal. They found that any person willing to accept, and capable of concentrating upon, suggestions from a hypnotist may be hypnotized.

Other investigators, several of whom came under Charcot's influence, made contributions which later were found to have significance for the understanding of normal personality. One of these was Janet, who introduced the concept of personality integration. He pointed out that psychoneurotics tend, as it were, to be divided within themselves, whereas normal persons represent an internal unity; that is to say, are integrated.

Freud, a Viennese physician who had worked with neurotic people before coming under Charcot's influence, developed the methods and concepts now known as *psychoanalysis*. He and an associate named Breuer had been using hypnosis to analyze and treat neurotic disorders. During the course of this work, Freud was impressed by the fact that a hypnotized person often remembers desires and experiences which are completely beyond recall in waking life. He was led to the conclusion that desires and past experiences of which we are not aware (which are unconscious) may influence our conduct. Among these, the sexual desires

were believed by Freud to be quite important. It was his contention that, even though we are taught from early childhood neither to think of sex, nor to express sex interests in any direct way, such interests nevertheless manifest themselves indirectly. Freud emphasized the importance of dreams as such indirect means of expression. He eventually ceased to use hypnosis as a way of finding out what unconscious motives and past experiences were bothering his patients. Analysis of dreams, and also free association — what patients said during sessions in which they were required to express everything which came to mind — were substituted for hypnosis.

Freud developed a number of ideas about neurotic and normal personality which, because they are based primarily upon observations of abnormal people and appear to rest upon insufficient proof, have been looked upon by psychologists as not scientifically demonstrated. Moreover, many psychologists and psychiatrists believe that, in his analysis of dreams and in his interpretation of everyday conduct, Freud overemphasized sex. They do give him credit, though, for having pointed out the influence of urges that are not recognized by the individual as determining his behavior, and especially of urges derived from childhood experiences. Many of the concepts and terms developed by Freud have filtered into almost every branch of psychology. Some of these we shall consider in Chapter 13.

We thus see that interest in hypnosis led to the study of neurotic people and finally to development of other methods than hypnosis for treatment of their ailments. Moreover, observation of the abnormal yielded many ideas later applied to interpretation of the normal personality.

The feebleminded

Feeblemindedness, like insanity, was once thought to result from supernatural influences. The feebleminded were frequently beaten to "drive the Devil out of them." Humane treatment, together with an attempt to understand the nature and causes of feeblemindedness and the best methods of educating individuals so afflicted, did not make very great progress until relatively recent times.

One of the most significant factors in the initiation of this movement was the attempt by Itard, a teacher of the deaf, to educate a "savage" boy whom hunters had found living like an animal in the woods of southern France. The boy was judged to be about ten years old when discovered in 1798. He was naked, walked on all fours, made unintelligible sounds, ate like an animal, and bit those who attempted to handle him. Pinel, the psychiatrist whose work with the insane we have already discussed, thought the boy mentally deficient. Itard, however, was interested in getting evidence on a controversy in which philosophers were engaged. John Locke had claimed that all ideas are, in the last analysis, derived from the senses, and that the mind is a *tabula rasa,* a blank sheet, until sensory experiences have left their impressions. The educational implication of the concept was that, in order to make an individual intelligent, the only requisite was to give him enough ideas of the right sort. Others argued that ideas are inborn, and that the function of education is not to pour in ideas, but to draw out those already present in germinal form. It occurred to Itard that, were he provided with sufficient ideas, the savage child might develop to the point where he could assume a normal position in civilized society. After five years of intensive training, however, the boy made such meager progress that Itard realized the hopelessness of his task. He concluded that the child was incapable of being civilized.

Itard's efforts had not been without effect, however, for the boy had learned to make new sensory discriminations, to recognize

objects, to understand a large number of words, to write a little, and even to read simple material, although with poor understanding of its meaning. He also learned a few simple motor skills. That the boy was feebleminded appeared certain. It was apparent that, while training led to improved adjustment, its influence was limited by the boy's deficiency. Whether the deficiency was inborn or merely due to early lack of educational opportunity could not be determined. Hence, the controversy which stimulated Itard's work was by no means settled.

When Itard took the "savage" boy into his care, diagnosed his deficiencies, and developed methods calculated to overcome these, he was initiating a movement which led to the development of clinical psychology, a field whose function it is to determine the basis of behavior difficulties of all kinds, and to suggest methods of correction. Many other men played an important part in this movement. One of them was Seguin, a pupil of Itard.

Seguin devised methods of training mentally handicapped children. When he came to this country in 1848, he was instrumental in establishing special institutions for the sympathetic care and training of feebleminded individuals. In the course of his work on the education of feebleminded children, Seguin devised his formboard, a device consisting of variously shaped openings into which appropriate blocks were to be fitted. Formboards of various kinds are now used in diagnosing the intelligence level of feebleminded and illiterate individuals.

The first psychological clinic for diagnosis and treatment of the behavior defects of children was opened at the University of Pennsylvania in 1896, under the direction of Witmer. Its express purpose was "the study and remedial treatment of mentally or morally retarded children, and of children suffering from physical defects which result in slow development or prevent normal progress." There are now many such clinics to which parents, schools, juvenile courts, and other institutions may bring children in order to discover the level of their intelligence, their aptitudes for various kinds of work, the nature of their behavior problems, and of their school difficulties. On the basis of his diagnosis of each individual's problems, the clinical psychologist gives advice calculated to remedy the defect. The development of such clinics, while given an impetus by the work of men like Itard and Seguin, has been aided in the present century by the development of psychological tests and special counseling procedures.

PSYCHOLOGY AND SOCIAL PHENOMENA

Psychological processes are functions of living organisms. Psychology is thus a biological science. The nature of its subject matter, however, brings psychology also within the general framework of social science. Psychologists are interested in many problems which sociologists investigate, and they in turn contribute to the general field of social science. Sociology and psychology therefore overlap in certain respects.

All but the lowest organisms are influenced by and influence the behavior of others. In other words, they exhibit social behavior. Man is pre-eminently a social organism. His very existence during the early years of life hinges upon services from other human beings, services which provide extremely intimate and almost continuous social contacts. These contacts transform his biological nature, his purely inborn nature, into socialized human nature. The content of his experience, the nature of his attitudes, the form of his conduct, and, in general, his personality, are thus products of social as well as biological influences. Even when human individuals become relatively independent of others, they not only maintain their social contacts, but extend them by forming associations, congregating,

and interacting in numerous ways. Such interaction, although many of its aspects are not readily brought within the laboratory or clinic, can hardly be ignored by a science whose scope includes investigation of human behavior.

Psychology must take into consideration two general social factors. One of these is the *influence of social environment* upon development of the individual's psychological characteristics. The other is *group behavior,* and the forms of interaction involved in it.

Influence of the social environment

Psychologists and sociologists have investigated the influence of home relationships, neighborhood contacts, friendships, and other social factors upon the development of individual characteristics. An understanding of personality, and especially of its abnormalities, requires reconstruction of the individual's earlier social environment. Moreover, when we are interested in comparing the psychological characteristics exhibited by individuals of one national or racial group with those of another, cultural environment is of great significance. Psychologists have sometimes concluded that certain psychological differences between races are inherited, only to discover later that they depend primarily upon diverse cultural environments. This is a field in which anthropology and psychology are mutually helpful.

Group behavior

Sociologists and psychologists have studied the behavior of crowds, audiences, nations, and other social groups. How group situations affect individual behavior has been observed both in everyday life and in the laboratory. Sometimes attention is not upon group behavior as such, nor upon the individual's reactions in a group situation, but upon the processes thus involved. Imitation, co-operation, competition, conflict, and other such processes of interaction have thus been investigated. Much of this work has been done with animals and children, as well as adults. Other social phenomena which come within the range of psychological investigation are fashions, fads, public opinion, prejudice, propaganda, censorship, certain aspects of religious behavior, and war. Concepts derived from work on hypnosis and suggestion have been found applicable in the interpretation of many such group phenomena.

The psychological investigation of social phenomena is a division of social science designated as *social psychology.* It lies, as we see, on the borderline between sociology and psychology. To sketch its origin would take us into the history of both sociology and psychology, but primarily sociology. This is because most of the early students of social behavior were sociologists. It was not until psychologists extended the scope of their investigation to include behavior as well as experience that they exhibited much interest in social phenomena.

THE DEFINITION OF PSYCHOLOGY

What we have already said about its history suggests the range of facts with which psychology deals, but a fully meaningful concept of psychological science can come only after such information as appears in this text has been grasped. But what of a formal definition? Is it possible to state in general terms the nature of the science of psychology?

Psychologists have experienced much difficulty in achieving a generally acceptable definition of their science. If one were to accept the literal meaning of the term "psychology" he would have to say that psychology is the science of the mind. But mind has always implied something like the soul, mystical and apart from the body. The

psyche of the Greeks, even when interpreted as a function of the body, is still invisible and thus beyond the realm of scientific investigation, for scientists are unable to investigate anything outside the range of their senses, or which cannot be brought within this range by means of language or with instruments such as microscopes, galvanometers, radio amplifiers, and cameras. Certain psychologists have even suggested giving up the title "Psychology" altogether and substituting something more in keeping with what psychologists actually do. Since psychology is now chiefly concerned with behavior, some have argued that "Behaviorism" is a more appropriate title. It has also been suggested that a better title would be "Anthroponomy," meaning "the science of human nature." But tradition is so strong that the term "Psychology" will doubtless remain.

The definition of psychology as "the science of conscious experience" was accepted for a time, but as the scope of psychology expanded so as to take in almost every aspect of behavior, such a definition became too narrow.

Students of behavior objected to the definition of psychology as "the science of conscious experience" not only because it failed to include their field of interest, but also because they regarded conscious experience as beyond the range of scientific observation.

The experiencing individual can alone describe his conscious experience. This is because it is private, *subjective*. But behavior may be observed and described by others. Information about behavior is thus social. It is, as we say, *objective*. Students of behavior argued that one cannot have a science dealing with something that is by its very nature private. Science, they claimed, can deal only with objective things. Thus, although nobody denied the existence of conscious experience, many denied that one could make a truly scientific (i.e., objective) study of it. For these two reasons, its narrowness and doubts about its scientific status, the definition of psychology as "the science of conscious experience" was given up.

Today psychology is most commonly defined as "the science of behavior." Interestingly enough, however, the meaning of *behavior* has itself been expanded so that it now takes in a good bit of what was formerly dealt with as experience. Thus psychologists who define psychology as "the scientific investigation of behavior" discuss vision, hearing, taste, smell, thinking, and even images, all of which are obviously aspects of experience.[5] But they deal with them from the standpoint not of experience but of behavior.

Let us take an example. If one of these psychologists flashes a colored signal light before your eyes, he is not interested in the nature or quality of your experience — for that is private, known only to you. He may be interested, however, in the fact that you can respond to the lights and the fact that you, like himself, can distinguish one color from other colors in the sense that you can alter your responses when the color of the signal is changed. You say "red" or "green," or you press one button for red and another for green, or you step on the brake for red and on the accelerator for green. The student of behavior believes that, when he has demonstrated that a man or an animal can distinguish two lights, as above, nothing is added to our scientific understanding by remarking that the lights produced different conscious experiences.

We see, then, that even when psychology is defined as "the scientific investigation of behavior," which is as good a definition as any, one does not ignore what was formerly dealt with as experience. We may add that such private (subjective) processes as thinking are now dealt with as "internal behavior." It cannot be overemphasized, however, that before the psychologist can make a

scientific study of such processes, they must be objectified. Thought processes, for example, are objectified when their presence is indicated by brain waves, language, or the solution of problems which require thought.

Psychology thus studies certain functions of the organism, as these are objectified through instruments or language, or other forms of behavior. The external responses are ordinarily referred to as "behavior." Internal physiological responses revealed by instruments are also referred to as "behavior." Language responses, as such, are designated "verbal behavior." When conscious experience enters the picture, it is inferred from verbal behavior. In the last analysis, everything with which psychology deals is reducible to activities of sense organs, nerves, muscles, glands and other bodily structures.

From the broadest standpoint, psychology is concerned with the overall adjustments of organisms to their environments. All responses, internal or external, are aroused by, and may be regarded as, adjustments to stimuli which impinge upon us. The importance of this lifelong process of accommodation is well expressed by Samuel Butler in his *The Way of All Flesh.*

> All our lives long, every day and every hour, we are engaged in the process of accommodating our changed and unchanged selves to changed and unchanged surroundings; living, in fact, is nothing else than this process of accommodation; when we fail in it a little we are stupid, when we fail flagrantly we are mad, when we suspend it temporarily we sleep, when we give up the attempt altogether we die.

WHAT PSYCHOLOGISTS DO

Most psychologists are primarily teachers. Many combine teaching with research. A few give all of their professional time to research. But there is a large and growing group of applied psychologists whose chief work is that of helping others solve their problems. These consulting and clinical psychologists work in public schools, colleges, and universities, mental hospitals, agencies of the Federal Government (like the Armed Services and the Veterans' Administration), guidance centers, churches, and in business and industry. Among their tasks are educational and vocational counseling; administering and interpreting mental tests; and diagnosing and remedying school disabilities, emotional difficulties, speech defects, and various other behavior disorders. Many, known more specifically as "industrial psychologists," are concerned with selection, training and public relations in industry.

Until trained psychologists took an interest in personal problems, these were often the grist of what have been referred to as "psychological racketeers" and members of the "psychological underworld." Almost every large city has its self-styled "psychologists" who, despite a lack of psychological training, advise people on everything imaginable. In her book *Where do People Take Their Troubles?* * Lee R. Steiner tells of her personal investigation of many such "psychoquacks." One man's justification for hanging out his shingle as a consulting psychologist was that he had been an inmate of a mental hospital and thus knew mental problems at first hand. One lady, who listened to people's problems for three dollars an hour, gave advice on marital difficulties. When questioned about her qualifications she said that she specialized in such problems because she had experienced a lot of trouble with her own husband. Some states now have laws which require certification of those who offer psychological services.†

* Boston: Houghton Mifflin Co., 1945.

† According to the Connecticut law, passed in 1945, no person may pass himself off as a certified psychologist until he has been certified by a board of three examiners in psychology. These examiners may require a written examination in psychology. The applicant must have a Ph.D. in psychology, or an equivalent degree, from a reputable institution of learning and, among several other requirements, must satisfy the board that he is of good moral

Qualified psychologists frequently work in close association with psychiatrists — medical practitioners who, as already suggested, specialize in the diagnosis and treatment of behavior disorders.

Thus not all that passes as "psychology" in everyday life is scientifically established. Among more specific psychological "rackets" that psychologists have investigated and found to have little or no basis in fact are *phrenology* (claiming to discern psychological traits by locating bumps on the skull), *physiognomy* (claiming to read character from such facial characteristics as the distance between the eyes, the height of the forehead, the shape of the nose, and so on), and *graphology* (claiming to determine the nature of complex psychological traits, including vocational skills, from analysis of handwriting). There are also certain "psychologies" for improving one's personality, "keeping mentally fit," or enabling one to "climb the ladder of success." Some of the principles involved in these "psychologies" have been borrowed directly from scientific psychology. Many of them are based upon the personal experience and, in many instances, imagination, of their authors. They have not been subjected by their proponents to experimental or other scientific tests. Only a knowledge of the well-established facts of psychology would make it possible for one to discover what, if anything, is sound in any of these "psychologies."

GENERAL PSYCHOLOGY

General psychology, with which we are primarily concerned, cuts across various fields in order to give a survey of the science of psychology as a whole. Chief stress, however, is upon: (1) typical psychological problems; (2) methods of investigating behavior in various organisms (animal, child, adult, normal, or abnormal) and (3) the functions involved in man's adjustment to his world. Special consideration is given to the fundamental facts of human nature and to the processes that may be discerned as operating in the typical human being. Anything which contributes to an understanding of these aspects and processes, regardless of the more specialized field of psychology from which it comes (animal, child, abnormal, clinical, or industrial) is the concern of general psychology.

SUMMARY

Psychology began with primitive man's questions about the causes of his experience and behavior. He was led to suppose that the phenomena of experience and behavior are caused by an invisible inner man. This naive conclusion was eventually displaced by the views of Greek philosophers. Of these Aristotle is especially notable because he interpreted experience and behavior as functions of the organism in response to stimulation rather than as manifestations of some invisible inner agent. Descartes gave even greater emphasis to the organism by regarding it as a mechanism controlled by external forces which, by affecting the sense organs and the nerves, cause muscles to contract or relax. Although he regarded the human mechanism as controlled partially by an immaterial agent, the soul, Descartes emphasized the response of organisms to their environment. Thus, Aristotle and Descartes both prepared the ground for a science of psychology.

Science collects facts, systematically

character. "Any person not certified as provided . . . who designates himself or his occupation by the words 'certified psychologist,' or by any other term which implies that he is a certified psychologist, shall be fined not more than five hundred dollars."

organizes them, and seeks their explanation. As long as experience and behavior were thought to be mysterious manifestations of an inner man, or of some other invisible agent, there was little desire to collect and systematize relevant facts. There was no need to seek for an explanation of psychological phenomena since the "explanation" was already given.

Sheer speculation about behavior and experience, even when it regarded these as functions of the organism, did not progress very far. It could not produce a body of well-established information, for those who speculated could not agree.

In physics and physiology, however, indisputable facts about nature, and about those aspects of it in which psychology is interested, were being discovered through use of experimental methods. Men could now repeat the investigations of each other, confirming or discrediting their results. A body of indisputable facts could be gathered, organized, and their relations determined. The possibility of placing psychology on such a scientific basis led Wundt to establish his psychological laboratory.

Wundt and his students attempted to analyze conscious experience by experimental means. With apparatus borrowed from physics and physiology, and later supplemented by new kinds adapted to their peculiar needs, they sought to describe the relations between aspects of experience, variations of stimuli, and sensory and nervous structures. They were, in a sense, attempting to determine the nature or "content" of consciousness.

Other investigators, without necessarily disparaging the aims of Wundt and his followers, became interested in the "functions" of consciousness. These psychologists believed, especially, that consciousness facilitates the learning process. They came to investigate this process in all of its aspects. Eventually, however, they studied learning as a form of behavior and paid relatively little attention to conscious processes.

Psychology finally extended its scope to include all kinds of behavior, whether manifested by the normal or the abnormal, by children or adults, by animals or human beings, by individuals or groups. Much of the work in these fields was experimental. That which did not lend itself to experimentation (for example, study of single cases and of crowd behavior) was nevertheless scientifically investigated whenever its study involved impersonal and systematic observation, organization of the facts observed, and an attempt to discover their explanation.

Psychology today concerns itself with the scientific investigation of behavior, including, from the standpoint of behavior, much of what earlier psychologists dealt with as experience. In the last analysis it studies the over-all adjustments of organisms. Courses in general psychology cut across the various specific branches or fields of psychology, like abnormal, social, child, and so on, so that the beginner may get a broad survey of problems, methods, facts, and principles. He might then obtain a more thorough understanding of himself and others, and thus become better fitted to solve the personal problems of adjustment which constantly confront him in everyday life.

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2 PSYCHOLOGISTS AT WORK

The Nature of Psychological Research · Naturalistic Observation · Experimentation: External and internal stimuli; control of the organism; the independent variable; the dependent variable; experimental and control groups; a limitation of naturalistic as compared with experimental procedures; the control of attitudes in psychological research · Clinical Procedures · Statistical Procedures · Summary

Students often ask, "Is psychology a science?" They know that astronomy, geology, physics, chemistry, and biology have traditionally been called sciences. But, as compared with the subject matter of these sciences, psychological phenomena seem so different, so intimately involved with oneself. Moreover, psychological problems were so long dealt with philosophically rather than scientifically, that a genuine doubt about the scientific status of psychology naturally arises. Even in colleges and universities, psychology is sometimes classified with the humanities and sometimes with the social sciences. Actually it is a natural science, closely related to biology, but also having intimate ties with the social sciences.

The scientific status of psychology, like that of every other science, natural or social, rests upon its methods — not on what it studies. Its methods are essentially like those of other natural sciences, but the nature of its subject matter introduces methodological problems which these sciences do not have. Here we consider some of these problems and also how psychologists handle them.

THE NATURE OF PSYCHOLOGICAL RESEARCH

Scientific investigation either deals with facts or is of such a nature that collection and systematization of facts offers a check on its correctness. Relevant facts do not, of course, arise spontaneously as needed. They must be sought.

Collection of information, psychological or otherwise, would be practically worthless if carried out in a purely random fashion. The psychologist does not search merely for facts. He seeks information about problems which interest him; problems which, if solved, would have practical or theoretical value, or both.

The nature of a problem is influential in determining the kinds of data to be gathered. If the problem concerns human sensory processes (e.g., vision, hearing), imagery, or emotional experience, the investigator may call for reports from his subjects, asking them what they see, hear, imagine or feel. If animals or human infants are involved, verbal reports are not available. The presence of internal processes may then be inferred from non-verbal behavior. Quite often, regardless of the nature of the subjects involved, interest centers solely on external behavior. The learning of motor skills, for instance, may be studied with reference to errors or successes, no attention being given to reports of experience. On the

other hand, an investigator of motor skill may supplement his objective data by calling for verbal reports.

The special problem under investigation may require information about an organism's history. For example: "What is the influence of man's animal ancestry upon his behavior?" "Is the individual's intelligence influenced by his heredity and if so to what extent?" "To what degree do influences brought to bear in childhood determine the personality of adults?" These and similar questions require what, in general, is referred to as the *genetic approach.* We say that a psychological investigation is genetic whenever it focuses upon the history of psychological processes. In gathering genetic information, one may utilize any or all of the more specific methods which we will consider shortly.

A psychologist does not, of course, start out to investigate psychological processes in general. He asks and attempts to obtain answers to specific questions. Suppose, for example, that the following question suggested itself: "What sort of organic modification occurs when learning takes place?" This is more specific than a general question about behavior, or even learning. But such a question, although focused on a particular aspect of behavior, is too general. Before he can start to work, the investigator must narrow his attention to questions which are still more specific. For example: "Which is the simplest organism capable of learning?" "What kind of cellular structures does this organism have?" "How does the learning of an animal who has these structures compare with that of an animal who has additional structures?" "What happens to a habit when particular parts of the brain are removed?" Each of these questions becomes the starting-point of a research project or perhaps of several investigations. It is only after many specific, yet relevant, questions have been answered, that significant light can be thrown upon the more general problem of how organisms are modified when they learn.

Investigations undertaken by all scientists usually have as their aim the discovery of general principles or laws from which predictions may be made. Certain investigations may, however, have practical rather than theoretical aims. In psychology, for example, an investigator may wish to learn the most efficient means of teaching shorthand. After his results have been obtained, they may be used to facilitate the teaching of shorthand. The investigation of such a problem, although it comes within the general framework of learning, is not motivated by a desire to understand the fundamental question of how man learns. Nevertheless, results obtained in pursuance of such a specific practical aim frequently add to our information about general principles, with which psychology, as a science, is most directly concerned.

Whether their interest is in internal or external behavior, whether it is confined to one stage of development or is genetic, and whether it is practical or theoretical, psychologists use some variation of the following methods: (1) *naturalistic observation,* (2) *experimentation,* and (3) *clinical procedure.* A further procedure, which may be used to help in analyzing and interpreting the data obtained by any of these three methods, is (4) the *statistical method.*

NATURALISTIC OBSERVATION

Many social and other forms of behavior must, if we are going to study them at all, be investigated as they occur naturally. The sciences of astronomy and geology are confined almost entirely to naturalistic observation; biology is obliged to use naturalistic, in addition to other means of, investigation. This is partly because events occur in nature which cannot be brought into the laboratory. Other events, if they occurred in the lab-

oratory, would be greatly distorted. This is especially true of certain psychological phenomena.

Let us consider a few questions which call for naturalistic observation by psychologists. Suppose that an investigator wished to study social interaction in a society devoid of culture. He would, of course, have to study animals, for even the most primitive human beings now living have a complex culture. If his interest were primarily in noting how men might act if deprived of all but their biological nature, the investigator would observe animals as much like man as possible; namely, anthropoid (manlike) apes.

Laboratory investigation would, of course, be out of the question. Even if it were possible, the results would obviously have little, if any, bearing on the question at issue. The psychologist's only recourse, then, would be to go to the jungle. There, without making his presence known to the animals, he could observe their social relations. A good investigator would not, however, set out for the animals' habitat until he had received training in scientific observation and had become as familiar as possible with available information on the animals he wanted to observe. He would also decide upon the specific question, or questions, to be answered. If possible, he would prepare to take moving pictures, so that he and others might study the behavior at their leisure.[1]

Having specific questions in mind is important, for no single person can concentrate on all aspects of social behavior at once. Relevant questions like the following might be asked: "How many animals appear in each family group?" "How many of these are adult males?" "How many are infants?" "Is the mating of given males restricted to particular females or is it promiscuous?" "Does conflict occur between individuals?" "If so, what form does it take?" "Do the animals co-operate?" In this way, the investigator, either in his thinking or in writing, has a "questionnaire" which his observations are to answer. His observations then are planned rather than haphazard.

Naturalistic observation is used in child psychology to answer such questions as: "What is the average age at which the first word is spoken?" "Do nouns or verbs predominate in the vocabulary of three-year-olds?"[2] "How do children of five years express anger?"[3] In abnormal psychology, questions like the following call for naturalistic observation: "What social conditions contribute to the incidence of insanity?" "What are the chief types of mental disorder?" Social psychologists use this method to study such phenomena as panics, riots, and public opinion.[4]

Other branches of psychology use naturalistic observation from time to time when the nature of the problem investigated demands it. In other words, they make an objective and systematic study of phenomena which occur without the investigator himself instigating them. Wherever possible, however, the method of naturalistic observation is supplemented by use of experimental procedures, for the experimental method offers advantages not possessed by any other.

EXPERIMENTATION

To discover the significant relations between the nature of the organism, its surroundings, and its psychological processes, all significant factors must be brought under the closest possible control. In other words, these factors must be subject to independent variation by the investigator. An experimenter cannot, like the naturalistic observer, wait for the experience or behavior in which he is interested to occur spontaneously. A naturalist has little, if any, precise information about factors which underlie the phenomena observed. He can describe behavior and note general conditions, but that is about all.

Psychological processes are influenced by many factors such as (1) the type of organ-

ism — animal or human, child or adult; (2) what has already been learned — skills and information; (3) the present condition of the organism — hungry or fatigued; and (4) stimuli — light and sound waves which fall within range of sensory structures. Typical experimental procedure changes one of these factors at a time, while holding the others constant. The effect of this variation is then recorded.

The type of organism to be investigated and its previous training are usually decided upon before the experiment proper begins. Therefore the chief factors to be varied or held constant in the experiment, once it is under way, are the stimuli and the general physiological conditions.

External and internal stimuli

What do we mean by a stimulus? Psychologically speaking, it is any factor, outside or inside the organism, but external to the living cell groups under consideration, which initiates activity of some kind. Aspects of the world which fail to arouse activity are not stimuli. Typical external stimuli are light waves, sound waves, contacts, changes in temperature, and odorous substances. Typical internal stimuli or conditions which influence neural activities are fatigue products, lowered blood sugar, presence of adrenalin in the blood, and nerve impulses which serve to arouse further nerve impulses.

Control of external stimuli is brought about by use of sound or light proof rooms and various types of apparatus. Control of internal stimuli may involve deprivation of food, administration of caffeine, injections of adrenalin, removal of the stomach to prevent contractions from serving as stimuli, cutting the spinal cord to prevent nerve impulses in the lower part of the body from reaching and stimulating nerve centers in the brain, and so forth. Obviously, controls like the latter, unless they occur by reason of accident, or disease, are possible only in animals. The animals are, of course, anesthetized to avoid pain.

Control of the organism

In addition to varying external and internal stimuli, the experimenter may vary the general condition of the organism. It is obvious that variations in internal stimuli come under this general heading. Some organic controls, however, are not directly in the nature of stimulus control. We shall mention just a few.

With adult human subjects, it is often necessary to develop a *set* or attitude before we present stimuli. That is to say, the individual is told to attend to one kind of stimulation and not others, or to react in one way to a red light, say, and in another way to a green one. He may be told that he is being tested for one thing, while he is really being tested for another; or that he is being given an injection of some drug, when the injection is really sterile water. He may be injected with a drug and with water in random sequence from day to day so that, on a specified day, he does not know what was injected. The chemist, physicist, and biologist do not have to worry about attitudes. But in psychological investigation with human adults, attitudes are extremely important and must be controlled.

Another control of the organism involves heredity. The investigator frequently desires that heredity be held constant. Suppose, for example, that he wishes to know whether children develop motor skills faster when given early training in these skills than when left to develop at their own pace. He must use two groups of children, one trained and one untrained; but he must use groups, which, if left to themselves, would presumably develop at the same rate. Rate of development, however, is influenced by heredity. Heredity must therefore be held constant. Identical twins have the same, or

essentially the same, heredity; hence, the factor of heredity may be controlled by using them for subjects. When identical twins are located and split into two comparable groups, one group may be trained, while the other is allowed to develop without training.

Identical twins are sometimes difficult to obtain and, in experiments with human beings, less perfect methods must sometimes be used for the control of heredity. We shall meet some of these other methods in our discussion of research on intelligence. Variation in heredity, while other factors are held constant, is accomplished by differential breeding, which is possible to control only in animals, or by selecting groups of human beings known to come from markedly different stock.

Control of the organism sometimes involves removal of structures, such as nervous tissue, glands, or sense organs. In such experiments, which are of course confined to animals, there is an operated and an unoperated group. Sham operations are frequently performed on the "unoperated group" so that all factors other than the crucial one (say removal of a specified bit of brain tissue) will be controlled. A comparison of the performances of the groups makes it possible to discover the function served by the part of the organism that has been removed.

The independent variable

It is customary to refer to the stimulating circumstance or condition of the organism that is varied as the *independent variable* of an experimental investigation. Except when special statistical procedures are used, there is only one independent variable in a given experiment, for, if an experimenter is to know the basis of the behavior or experience in which he is interested, he must discover the changes produced by each separate factor. If two or more factors were varied at the same time under conditions where their separate influence could not be discerned, he could not know which had produced the phenomena observed.

Even when the experiment is statistically designed so that more than one factor may be varied at a time, statistical analysis isolates the influence of each factor.[5] With statistical procedures, however, the interdependent action of more than one variable, with relative contribution of single variables may also be studied.*

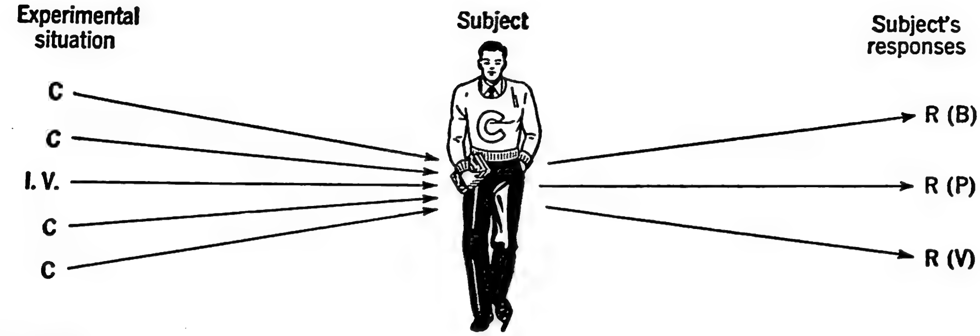
The dependent variable

Responses are the dependent variables of an experiment. In addition to varying a stimulus or an organic condition, while other stimuli and organic conditions are held constant, the investigator observes responses. In many instances, he measures the responses which have resulted from his manipulations of stimuli or organic conditions. These responses are the *dependent variables* of an experiment. They depend, in other words, upon the factor whose isolated influence is studied by the investigator.

The organism experimented upon is customarily referred to in psychological investigation as the *subject*. Responses (or reactions) of the subject may, for purposes of convenience, be classified under one or more of three headings: (1) *Gross behavior* which any observer may see, such as traversing the pathway of a maze, typing, speaking, pressing a key, or blushing. (2) *Internal physiological activity*, such as accelerated heartbeat and increased blood sugar, which must be ascertained by means of instruments or chemical tests. (3) *Verbal descriptions of experience*. These descriptions are of thought processes, sensory processes, feelings, and other internal psychological activities.

Sometimes an investigator is interested in

* The details of statistical experimental design are too complicated for treatment outside of books on advanced statistics.



6

Schema of a Typical Psychological Experiment

I. V. *is the independent variable, which the experimenter manipulates (e.g., adding or subtracting it from the situation, or varying its amount). Practice, alcohol, hunger, and visual stimulation are examples of such variables. The C's are constant factors. Thus, in an experiment to assess the effects on reasoning of a certain amount of alcohol, such factors as the age, sex, intelligence and previous indulgence of the subjects would be held constant. Likewise, the amount of alcohol, the test of reasoning, the time since drinking that it is administered, and methods of scoring results would need to be the same for all subjects. Still another of many factors to be held constant would be the attitude of the subjects. The alcohol should somehow be disguised so that subjects did not know when they were getting it and when a non-alcoholic beverage was being drunk. The* R*'s refer to dependent variables, in this case, psychological changes produced by alcohol.* R(B) *refers to gross behavior variables (like muscular steadiness, speed of reaction, motor co-ordination, and performance on learning and reasoning tasks).* R(P) *represents internal physiological changes such as heart rate, secretion of adrenalin, and brain waves. By* R(V) *we refer to what the subject says in describing his experiences, such as feelings of clumsiness, nervousness, or exhilaration.*

only one kind of response. At other times, he is interested in and simultaneously collects data on several aspects of behavior. It is apparent, then, that a particular experiment may, and it often does, involve several dependent variables. A typical experiment is schematically represented in Figure 6.

Experimental and control groups

We have already suggested that many experiments require two or more groups. In an experiment using identical twin infants, split into two groups, one trained and the other not, the trained infants are referred to as the *experimental group* and the untrained as the *control group*. Sometimes instead of using separate experimental and control groups, the experimenter studies the behavior of one group under both the experimental and the control conditions. The experimental group, or condition, is always the one involving some variation from normal or usual circumstances, while the control group or condition is the one in which this variation does not occur. In all respects other than the experimental variable, the groups are comparable. Quite often more than one experimental group is involved in an investigation. Thus, if we were to study the effect of deprivation of sleep on muscular steadiness, we might have one group (control) tested after sleep, and separate, but comparably constituted, groups (experimental) tested after, respectively, twelve, twenty-four, forty-eight, and ninety-six hours of sleeplessness. Here we would be interested not merely in how deprivation of

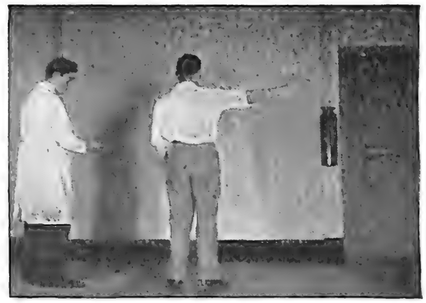
sleep impairs muscular steadiness, but in how the degree of impairment varies with the degree to which subjects have been deprived of sleep.

A limitation of naturalistic as compared with experimental procedures

The value of experimental as compared with naturalistic methods is highlighted by an experiment on how the blind avoid silent obstacles.[6] There have been naturalistic observations of blind people for centuries and the blind have themselves wondered how they so readily avoid obstacles, even obstacles met for the first time. On the basis of such observations many theories have been propounded, including the theory that blind people have an unusual sensitivity of the facial skin and nerves which enables them to perceive the closeness of obstacles through pressure of air on the face. This is the "facial vision" theory.

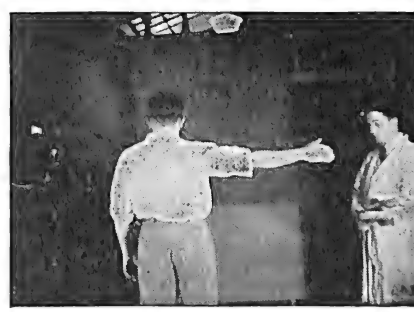
The experiment to be described was designed to test this theory. Both blind and seeing subjects were used, the seeing subjects being blindfolded. The blind subjects, although able to sense the proximity of obstacles, did not know how they did it. Seeing subjects were at first unable to locate obstacles when blindfolded, but they learned to do so. They did not know on what basis this ability was learned.

After preliminary experiments (Figure 7) in which the subjects were tested to see (1) at what distance they first perceived a wall and (2) how close they could approach without touching it, various tests were carried out in an effort to discover the basis of these performances. A movable masonite screen was used and the subjects were led around in various ways in an effort to disorient them before they faced the screen. In each test, the screen was moved to a new position. These changes prevented neither the blind nor the blindfolded seeing subjects from sensing the screen's location.



A

B



C

7

Perception of Obstacles

A. *A blindfolded subject signals, by raising his right hand, that he senses the wall ahead of him.* B. *He raises his left hand to signal that he is about to make contact with the wall. The experimenter, by reading the floor marks, records the distance at which the wall is first perceived and the distance at which imminent contact is sensed.* C. *Here a movable masonite screen is used in place of the wall. (From Supa, M., M. Cotzin, and K. M. Dallenbach, "Facial Vision: The Perception of Obstacles by the Blind,"* Amer. J. Psychol., *1944, 57, pp. 142 and 152.)*

When the subjects had to approach the screen in their stockinged feet, thus cutting down the loudness of sounds made while they walked, there was a marked decrease in accuracy of localization. All subjects sometimes bumped into the screen. This confirmed the idea of one blind subject that hearing had something to do with accuracy of performance. However, "facial vision" was still theoretically possible. A direct test of this possibility involved experiments in which the subjects had head and face completely covered with a layer of felt (Figure 8). They also wore gauntlets so that air pressure on the hands would be eliminated. Despite elimination of air pressure in these ways, and also a reduction in the intensity of sound, the screen was still perceived with a high degree of accuracy. Facial vision was thus ruled out as a necessary aspect of the perception of obstacles. But when hearing was eliminated, either by blocking the ears or by introducing a constant sound (Figure 8), all subjects ran into the screen on all tests. Thus hearing was shown to be necessary to obstacle avoidance.

A

B

C

8 **Control Experiments to Test the Use of Touch and Hearing**

A. *Notice that the subject's head and shoulders are covered and that he wears gauntlets.* B. *A constant 1000 cycle tone stimulates the ears. Now, as shown in picture* C, *the subject walks into the screen.* C. *A subject, with ears blocked, does not sense the screen until he bumps into it. (From Supa, Cotzin, and Dallenbach,* ibid., *pp. 161, 169, and 173.)*

That hearing is alone necessary for accurate localization was shown in a further experiment (Figure 9) in which the subject sat in a sound proof room wearing earphones while the experimenter, with eyes closed, carried a high fidelity microphone toward the screen. When the experimenter reached a certain distance, the subject said (through a microphone system) that he sensed the obstacle. Then, as the experimenter moved his microphone close to the screen, the subject told him when he was about to touch it. Thus all that is necessary for correct localization of a silent obstacle is reception of sounds made by the feet as the obstacle is approached. Tapping a cane, snapping the fingers, and clicking the heels are often used by the blind to help them to find their way around obstacles. We now see why this is so, and it does not surprise us to learn that, in a later experiment, blind-deaf human subjects did not learn to avoid the obstacles.[7] Other experiments have shown that it is the higher frequencies (higher pitched sounds) which enable the blind to avoid obstacles.[8]

9

Perception of Obstacles by Sound Alone

The experimenter walks toward the obstacle holding a high fidelity microphone (top picture). Sounds picked up by this microphone are conveyed to the ear-phones of the subject, who is seated in a sound proof room (bottom picture). He speaks into a microphone to let the experimenter know when the obstacle is perceived. (From Supa, Cotzin, and Dallenbach, ibid., *p. 176.)*

These are produced by footsteps, breathing, and sources in the environment. They are reflected back by the obstacles. These are avoided through detection of the sources of reflected sound waves. Bats avoid obstacles in a similar fashion. They produce sound waves of too high a frequency for human ears, but these enable them to locate the sound-reflecting obstacles.[9]

We thus see that carefully designed experiments may reveal specific information which enables us to choose between rival theories. Naturalistic observation, since it provides little or no control over underlying conditions, does not so readily serve this purpose.

The control of attitudes in psychological research

We have mentioned that psychologists must control the attitudes of their subjects. Here is an illustration of the need for such control. Several years ago a well known investigator in the field of pharmaceutical chemistry gave a lecture in which he described the following experiment.

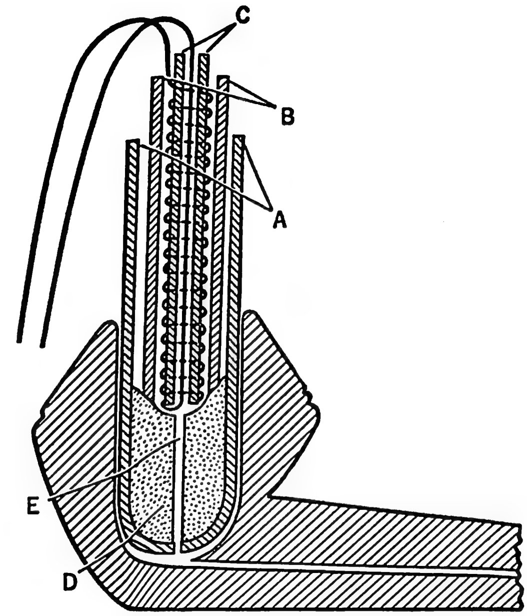
A group of students was injected on some days with a certain highly publicized drug. On these (experimental) days, as well as on others (control), when the drug was not injected, the students were given a variety of psychological tests. Comparisons of their performances on drug and non-drug days revealed a higher level of efficiency on the former. The investigator therefore concluded that the drug has beneficial psychological effects. But members of the audience were quick to challenge this conclusion on the grounds that the students knew when they were getting the drug and had already had its beneficial effects suggested to them. It was claimed, quite properly, that the beneficial effects might have resulted not from the drug itself but from (1) suggested potency, (2) expectation of beneficial effects, and (3) increased effort induced by suggestion and expectancy. How could the professor have avoided this criticism? He could have done so by injecting the subjects every day, but on some days with the drug and on others with sterile water; not, of course, letting them know when the drug was administered. Under these conditions, if other necessary controls had been instituted, the effect or non-effect of the drug would have been revealed by a comparison of performance on drug and non-drug days.

The ingenuity which is sometimes called for in arranging such experiments is well revealed by a study of the effect of tobacco smoke on psychological reactions.[10] Suppose the subject believes that smoking is harmful. He might expect it to retard his perform-

ance and thus he might put forth less effort than normal. On the other hand he might desire to prove that smoking actually helps him, hence put forth more than normal effort. Obviously, then, the subject must not be allowed to know when he is and is not smoking. While this sounds impossible of accomplishment, nevertheless the requisite control was very neatly carried out, utilizing the specially devised control pipe shown in Figure 10 and a pipe identical in all respects except that it actually contained tobacco. The control pipe furnished warm moist air which, with a little tobacco smoke in the room, could not be distinguished from actual tobacco-filled air. The illusion that the subjects smoked in tobaccoless as well as tobacco sessions was also aided by the following controls: the subjects were always blindfolded during the experiment. The experimenter made as much noise — such as scratching matches, knocking pipe, etc. — on tobaccoless as on tobacco nights. The pipe was placed in the subject's mouth, held there while he smoked, and withdrawn by the experimenter. The subject was required to blow the smoke out without inhaling. He was told not to swallow his saliva. The experimenter himself smoked during non-tobacco sessions so that the proper odor would be present. Finally, when the subject completed a session and the blindfold was removed he always saw the burnt-out ash in the pipe that, presumably, he had been smoking. Reports from the subjects after the experiment was complete proved that they were never suspicious of the fact that merely warm moist air was being "smoked" during some sessions. One subject actually went through the motions of blowing smoke rings while "smoking" the tobaccoless pipe.

The outcome of this experiment, incidentally, was that smoking did not significantly influence most of the psychological processes studied. It did, however, bring a significant decrease in muscular steadiness.

These illustrations provide a fairly good idea of the experimental method in general, especially of some important types of control which investigators of adult human psychology are called upon to use. Each experiment, however, requires specific controls more or less peculiar to it; hence, one should not get the idea that every experiment involves only, all, or most of the controls mentioned above. When the subjects are animals, controls like most of those in the above experiments are of decreased importance. On the other hand, organic conditions — hunger, thirst, injuries to the organism, and so on — not involved in these studies, may assume much importance in investigations with animals.



10 **Control Pipe Used in Research on the Psychological Effects of Tobacco Smoking**

A *is an aluminum capsule;* B, *an outer asbestos tube;* C, *an inner asbestos tube;* D, *plaster moistened with water; and* E, *the hole through which the warmed and moistened air passed. (From Jenkins, J. G.,* Psychology in Business and Industry. *New York: Wiley, 1938, p. 138. After a description by Hull.)*

CLINICAL PROCEDURES

You will recall from what was said earlier that clinical methods are applied to a particular individual or case. They are used for practical purposes: namely, the diagnosis and treatment of a disorder which brings the person to the clinician. We have already pointed out that only after many cases are compared may information of general theoretical significance be apparent. Our chief interest here is in noting the kinds of information which clinical psychologists gather for their diagnosis.

The clinical psychologist frequently uses standard tests which might throw some light on the nature of the problem confronting him. If a boy is making poor progress in school, it may be because he has low intelligence, because his hearing is poor, because he is slow to react, or because he makes more than the normal number of eye movements in reading. Measurement under standard test conditions is the only reliable means of determining the nature of an adjustment problem resulting from low intelligence, or from sensory, motor, and other organic deficiencies.

But the problem may result partly or wholly from such factors as poor early training, bad school conditions, inadequate home environment, or undesirable social relations in the neighborhood and community. Information about these may be revealed by a case history.

The individual's past is usually reconstructed in the form of a biographical account. Data for the biography are gathered from interviews with the individual and with his associates. Workers especially trained for the task frequently obtain information relating to his immediate social situation.

The results of relevant tests, the biography, and information about the immediate social setting of the individual's behavior, usually place the clinical psychologist in a position to discover the sources of trouble and to make suggestions for correction of the behavior problem.

The following digest [11] of a clinical case history should give some idea of how clinical psychologists work. This should not, however, be regarded as a typical case history, for every case presents different problems and calls for somewhat different procedures.

Louise, age three years nine months, is extremely negativistic, stubborn, persistent and has temper tantrums. An interview with the parents showed them to be emotionally upset and to blame each other for failure to manage the child. They were subsequently given separate interviews. An aunt and a nursery school teacher were also interviewed. During these interviews the child's mother revealed such information as her family background; how she met her husband; that Louise had a normal birth; that she disapproved of her mother-in-law living with them; that the mother-in-law, who failed to help with the housework, spent "endless hours" with Louise; and that the child had chronic constipation, terrible temper tantrums during which she threw herself on the floor, screamed, kicked, and attacked others, and was extremely difficult to get to bed. The mother did not want to discuss her marital adjustment. A social worker found that the mother-in-law did not hesitate to criticize the mother's friends, her housekeeping, and the way she handled Louise. The mother showed no warmth in speaking of her child.

Louise was about two when her behavior problems began. At three she would not play with blocks, dolls, and the usual playthings of a three-year-old, but she loved to have stories read to her. The mother selected the books, including *Alice in Wonderland, Oliver Twist* and *Pilgrim's Progress* — books hardly suitable for that age level. Louise never played with other children. When brought together with them she did not get along. She almost strangled one child. Her preferred companion was her father, with whom she liked to go for walks, but she attacked even him when having a temper tantrum. Once, when he was talking to someone else and failing to give her the at-

tention Louise demanded, she bit him in the leg through his trousers.

The interview with the father, who seemed self-conscious and ill at ease, showed that he was very proud of Louise. He thought her very bright and he spoke of her attentions to him, in which she acted "just like a grown woman." He expressed doubt about her happiness and whether she felt secure.

Physical examination of the child revealed no physical abnormalities except slight overweight. The constipation was believed by the physician to result from faulty diet and management. Thumb-sucking, nail-biting and hair-twisting were evident.

When her father brought her to the clinic, Louise was charming, feminine and dependent. When her mother brought her she was forthright, independent and domineering. Sometimes there was a scene as, for example, when she responded to her mother's request to put on her coat, by lying, screaming, on the books she had been looking at in the office.

Psychological tests showed Louise to have almost an eight-year-old vocabulary, and intelligence far above the average. Her language abilities were far more developed than her motor skills.

The clinical psychologist's diagnosis was as follows: "This is a well-developed, bright child of domineering personality, accustomed to far too much adult attention and companionship, with poorly established routine habits creating a condition of chronic fatigue, and surrounded by an unfortunate series of parent-child and adult relationships contributing to confusion and negativism. There had been no consistent opportunity for her to adjust to other children, and there was overdevelopment of a restricted type of intellectual activity at the expense of variety of experience. Her abilities appeared to be unevenly developed, verbal far outstripping motor abilities. Of her inadequacies she was well aware, and these made adjustment on a child level particularly difficult for her. She appeared to the clinic staff to be a much-fatigued little child tyrant, rejected emotionally by her mother, and well on her way to developing a severe emotional fixation upon her father."

The chief recommendations of the psychological clinic were as follows: That friendly relations should be established with the mother and help given her in the reorganization of Louise's home life. This included provisions for more sleep, a balanced diet, outdoor exercise and play, especially with other children, and individual attention from some member of her family (alternated between father, mother and grandmother) for a period each day just before the evening meal. The mother was to be made to feel that she was responsible for Louise's improvement, but the father, mother-in-law, and aunt were interviewed and induced to alter their own routines in the interest of improving the relations between Louise and her mother. The child was enrolled in a nursery school, with arrangements between clinic and school so that her temper tantrums would not bring dismissal before she had been given a chance to improve. Great difficulties were experienced before Louise adjusted to the nursery school. A follow up study over the years showed Louise to be a leader in many activities, scholastic, Scouts, Red Cross, etc., but she did not completely overcome her earlier difficulties, including her lack of affection for her mother and her strong attachment for her "daddy." At fifteen she "is a handsome girl who carries herself well and has an air of great competence. She has no nervous habits. . . . Her greatest pleasure according to her own reports is 'doing things with Daddy.' . . . The man she dreams of marrying is 'just like Daddy.'"

Although a particular method may be more relevant to some psychological problems than to others, many problems require use of all three methods. Thus, a psychological research frequently involves naturalistic, experimental, and clinical material. In other words, a psychologist, in investigating the problems which interest him, utilizes any or all reliable means of gathering his information.

STATISTICAL PROCEDURES

Statistical analysis is an application of mathematics which enables the psychologist to arrange his findings so that he can discover their significant trends and relation-

ships. As we have already indicated, psychologists first used statistics in the study of individual differences. Today, however, the statistical method is an indispensable tool in several fields of psychology.

Statistical devices are used to supplement naturalistic observation, experimentation, and clinical procedure. Suppose, for example, that a naturalistic observer notes the number of times person-to-person conflict occurs in each of a hundred groups which differ in size. If he wishes to know the average number of conflicts per group, the average size of groups, or the relation between the size of the group and the number of conflicts within it, he must resort to statistics.

In designing experiments and interpreting experimental data, an investigator often needs the aid of statistical procedures. He needs such information as how many experimental groups are necessary, and the requisite size of groups in order to obtain reliable results. When he has his data, the experimenter often needs to determine trends and relationships, and even the probability that he will get different or similar results in a repetition of an experiment.

Statistical procedures are indispensable, also, in standardization of intelligence, personality, and other psychological tests, for they disclose the degree of relationship between test scores and other things: success in school, flight performance, social adjustment. In clinical practice, moreover, the interpretation of an individual's performance on standardized tests is to some extent dependent upon prior statistical analysis of scores made by large groups of individuals. The individual score, in other words, is compared with norms (namely, averages determined for large groups which represent the population at large). We have already referred (p. 29) to the fact that experimental psychologists may use statistical procedures so as to deal with more than one variable at a time.

Statistical procedures, and interpretations based upon statistical analysis, are too involved for adequate presentation in an elementary course. However, a brief introduction to them is given in Chapter 21.[12]

SUMMARY

We have observed that psychologists, if they are to obtain scientifically sound information concerning psychological processes, must make planned observations which are focused upon specific problems. These problems are usually framed as questions to be answered. If a question refers to what the subject sees, feels, or thinks, the investigator asks him to give a verbal description of his experiences. If the psychologist's question pertains to external behavior, on the other hand, he observes and records such responses as success in hitting a target or in reciting what has been memorized.

Whenever a problem requires knowledge of the past history of psychological processes, the investigator makes a developmental or genetic study. He may, for example, observe development of psychological functions in animals ranging from lower to higher; or in an individual from one stage of growth to another.

The ultimate aim of psychology, as a science, is to determine the laws of human nature; and in this connection the stimulating and organic conditions of which psychological processes are functions. Such an aim does not preclude solution of practical problems, like discovery of the most efficient methods of learning or the best means of enabling one to avoid psychological ills.

The practical and scientific aims of psychology are achieved by use of methods which may be designated as (1) natural-

istic, (2) experimental, and (3) clinical.

When one wishes to study behavior which either could not be produced in the laboratory or which would be distorted if produced there, naturalistic observation is the only available method. In using this method, the investigator observes behavior as it occurs spontaneously; that is, without his instigation. Observations are not haphazard, however, for specific questions must be answered. Naturalistic observation is widely used in studies of social behavior. Sometimes it precedes experimental investigation, providing preliminary information by which experiments can be designed.

Experimental methods in psychology are techniques for controlling factors which influence the subject's reactions. Such factors are: (1) the kind of organism, (2) its previous training, (3) its condition at the time of observation, and (4) the stimuli, both external and internal, which activate it. In a typical experiment, such factors are varied one at a time, while others are held constant. This is what we mean by experimental control. The varied factor is referred to as the independent variable of an experiment. Responses of the organism, whether in the nature of verbal reports, physiological changes, or gross behavior, are designated as dependent variables. The experimenter's task is to discover the stimuli and organic conditions upon which these responses depend. With modern statistical procedures, too complicated for elementary discussion, experiments can also be designed to test the separate or interrelated influence of more than one variable at a time.

Clinical methods are used to diagnose behavior difficulties in individuals; hence, their immediate aim is practical. In gathering data for his diagnosis, the clinical psychologist uses standard psychological tests; reconstructs, as it were, the individual's history; and gathers information on the social situation which surrounds the individual. By these means an attempt is made to locate the sources of difficulty and to make suggestions concerning corrective measures.

No psychologist necessarily confines himself to a particular method of approach. Any method, or combination of methods, which promises information of value in solving psychological problems is utilized.

Statistical procedures provide a means of designing experiments and of analyzing and determining the significance of results after these have been gathered by the methods described. Some of the simpler statistical procedures will be described when we come to the discussion of intelligence, aptitude, and personality, fields in which they are most widely used.

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2. See, for example, McCarthy, D., *The Language Development of the Pre-school Child.* Minneapolis: University of Minnesota Press, 1930.
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4. Two examples are: Cantril, H., H. Gaudet, and H. Hertzog, *The Invasion from Mars.* Princeton: Princeton University Press, 1940; Veltfort, H. R., and G. E. Lee, "The Cocoanut Grove Fire: A Study in Soapegoating." *Clinical Supplement to the Journal of Ab-*

normal and Social Psychology, 1943, 38, pp. 138–154. An abbreviation of the first of these, together with other examples, is to be found in Newcomb, T. M., E. L. Hartley, *et al., Readings in Social Psychology.* New York: Holt, 1947, chap. XV.

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11. Paraphrased and partially quoted from a report, "A Behavior Problem in a Young Child," by Katherine M. Maurer. The complete report appears in Burton, A., and R. E. Harris, *Case Histories in Clinical and Abnormal Psychology.* New York: Harper, 1947, pp. 530–547.
12. Some instructors may wish to introduce a more detailed discussion of statistics at this point, assigning Chapter 21 now instead of later in the course. If this is not done, the student may make at least a rapid survey of the statistical chapter to supplement what he has just read.

SUGGESTIONS FOR FURTHER READING

Andrews, T. G. (Ed.), *Methods of Psychology.* New York: Wiley, 1948.

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Part Two

The Organism: Its Growth and Psychological Significance

Everything that the psychologist studies is a function of the organism. We behave like human beings because we have human sense organs, human brains, and human muscles and glands — in brief, because we have human response mechanisms. As these mechanisms have evolved, so also have our psychological processes, including what we call intelligence.

Although the organism is involved in everything studied by psychologists, the psychologist does not necessarily focus his attention on the organism as such. He makes no attempt to take over the task of anatomists, physiologists or neurologists. Indeed a great deal of psychology stays on the level of behavior — on the level of stimulus and response — making no reference to underlying organic mechanisms. In an analogous fashion, one could learn to predict and control the behavior of a car without knowing anything at all about its engine and the various other mechanisms under the hood. Thus we may focus on such problems as how reaction time varies with the number of things to be attended to, how such and such rewards influence industrial output, and how a certain kind of early training influences the adult personality. No reference to underlying mechanisms is necessary in such cases.

But suppose we want to know how or why some reaction occurs. If we want to learn how the car acts as it does we study its mechanisms. Likewise, if a psychologist is interested in understanding why such and such stimulation brings certain behavioral results, he must turn his attention to sense organs, the nervous system, and muscles and glands. If the particular information that he seeks has not been revealed by physiologists or neurologists, he may undertake the necessary investigation himself. Indeed much neurological research is an effort to discover the underlying mechanisms of behavior. With this aim, psychologists

and psychologically oriented neurologists and physiologists are making important discoveries in their fields of psychoneurology and physiological psychology. Some of the fruits of their efforts are considered in the following chapters.

When our car fails to function properly we suspect that something has gone wrong with the mechanism. Likewise, when people suffer a psychological breakdown we look for some organic defect. Failing to find it, we may attribute their difficulties to poor early training, bad habits, or wrong attitudes. "Functional" disorders such as these were referred to in our first chapter. But many behavior disorders result from defective mechanisms. Some of these disorders, as well as their organic bases, are considered in our discussion of brain mechanisms.

Response mechanisms are the connecting links between stimulus and response. Whenever the psychologist seeks a biological explanation of what he studies, or whenever he wishes to discover the cause of behavior disorders, he probes into the response mechanisms.

Chapter 3 is an elementary survey of mechanisms important to an understanding of why we behave as we do. It is not designed to teach anatomy, physiology or neurology, but rather to point out the significance of some psychologically important anatomical, physiological, and neurological mechanisms to which reference will again be made in later discussions of learning, reasoning, emotion, perception, and sensory processes. A certain minimum discussion of response mechanisms is required. Otherwise the student who knows nothing about (for example) the nervous system "will invent an inferior nervous system for himself as a means of correlating the facts of psychology which he learns." *

Chapters 4 and 5 continue the study of the organism, but from the standpoint of how the individual and his psychological processes grow. These chapters offer a brief introduction to the field of psychological development — or genetic psychology. Chapter 4 traces development of the organism from conception to maturity and, after behavior has appeared, correlates its growth with that of the organism. Chapter 5 deals with the respective roles of heredity and environment in development and also introduces the important concept of maturation. In this, as in other chapters, attention is given not only to facts but also to how they are discovered.

* *The Place of Psychology in an Ideal University.* Cambridge: Harvard University Press, 1947, p. 13.

3 THE ORGANISM VIEWED PSYCHOLOGICALLY

Evolution of Reaction Mechanisms: Receptors; effectors; nervous mechanisms; central nervous mechanisms; evolution of the brain • The Nerve Impulse: The doctrine of specific nerve energies; the nature of the nerve impulse • The Human Nervous System • The Human Brain • Interconnecting Circuits • The Human Cerebral Cortex: Cortical rhythms; locating special brain functions • Sensory Functions of the Cortex: Somaesthetic sensitivity; visual sensitivity; auditory sensitivity • Motor Functions of the Cortex • Associative Functions: Speech functions; frontal association areas • Summary

We have seen that emphasis on mind as a function of the organism played an important role in the development of psychology as a science. Today all psychological processes are dealt with as responses of organisms to stimulation. This fact is often represented by the formula S O R, where S represents stimuli; O the organism; and R the organism's response.

Psychologists may focus upon: (1) the internal or external stimulating conditions which arouse a response; (2) the organism which responds; or (3) the characteristics of the response itself, which, as we have seen, may be internal or external. It is obvious, however, that aspects of the world are not stimuli until they act upon an organism; and that responses do not exist in a disembodied state, like the grin of the Cheshire cat in *Alice in Wonderland.* Thus the organism and its characteristics are of central importance for psychology.

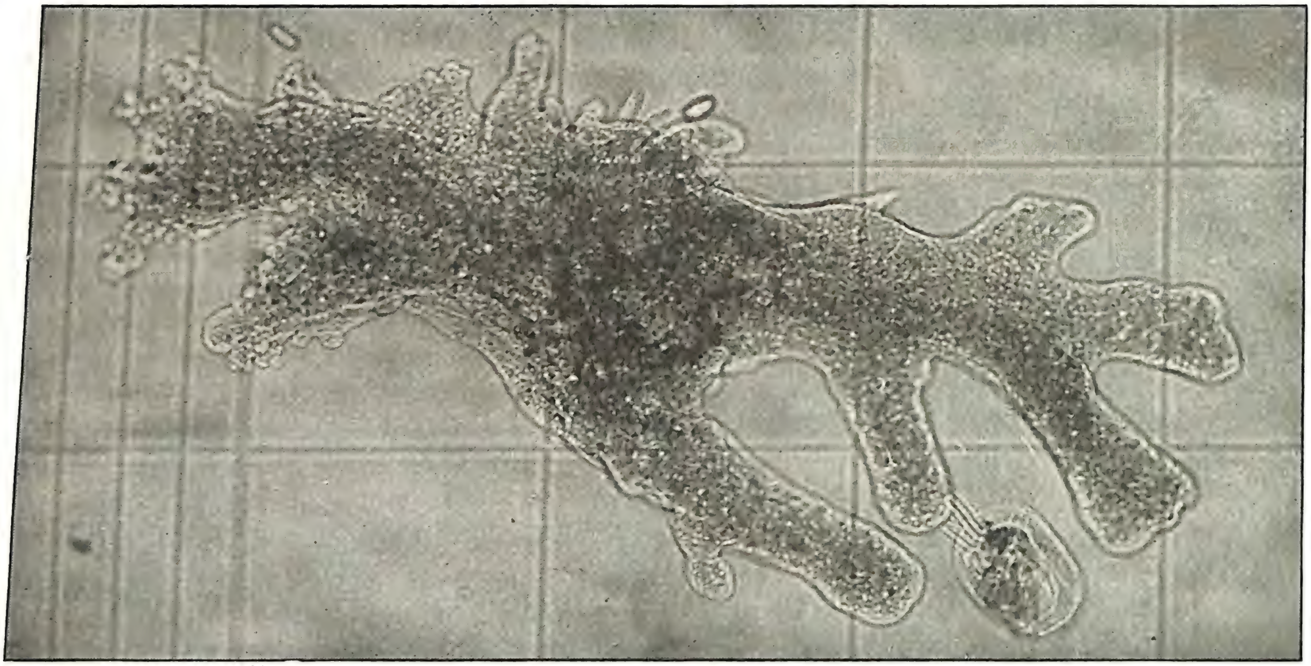
EVOLUTION OF REACTION MECHANISMS

A good way to learn the psychological significance of our mechanisms of reaction is to trace them from their beginnings in lower animals. The structures of special interest psychologically are the *receptors* (sense organs), the *effectors* (muscles and glands) and the *nervous system* (brain, spinal cord, and nerves).

Some animals, of which ameba is a good example, have no specialized receptors. Their whole body surface is sensitive to light and other stimuli. Since ameba lacks specialized receptors, it is sensitive to its environment only in a very limited way. It is, for example, sensitive only to the brightness, direction, and movement of light. Characteristics of stimuli which in higher animals give rise to perception of color, shape, and other details of objects are lost on ameba because the animal has no receptors attuned to them. Since it has no ears attuned to air waves, it is completely deaf. In other ways, also, ameba and similar animals have a very limited sensory horizon.

From a motor standpoint ameba is similarly at a disadvantage. Any part of its body may become a fingerlike projection enabling it to move (Figure 11), but it has no specialized effectors, like legs, arms, wings, or hands, and thus it can neither move around in nor manipulate its environment like animals having such effectors.

Ameba also lacks a nervous system, the mechanism which, in higher animals, conducts impulses from receptors to effectors and serves, in general, as a co-ordinating



II

The Ameba

An ameba is a single celled organism which combines within itself, insofar as the properties are shown at all, the capacity to serve as a receptor, as an effector, and as a conductor of the results of stimulation. This photomicrograph shows the ameba extending long pseudopods toward another microscopic organism. Each of the large ruled squares in this picture is one-hundredth of an inch on a side. (From Buchsbaum, R., Animals Without Backbones, *Revised Edition. Chicago: University of Chicago Press, 1948, p. 14–1. Photo by Ralph Buchsbaum.)*

device. A nervous system not only conducts, but it is also modified by what happens to the organism. This modifiability underlies learning, memory and reasoning. Having no nervous system, ameba has little or no ability to learn or to exhibit higher psychological processes based upon learning.[1]

Receptors

Specialized sense organs, or receptors, make their appearance in animals a little higher than ameba. Initially crude and sensitive to very restricted aspects of the environment, the receptors become highly complex organs attuned to a wide variety of stimuli. The first eye, for instance, is a single small pigment spot that is more light-sensitive than any other part of the body. In still higher organisms we find a grouping of such light-sensitive organs, each at the bottom of a small pitlike depression. From this "compound eye" we go to a cup-like opening with highly developed light-sensitive organs at the bottom. In the higher forms, the cup-like depression has a fixed-focus lens. Our own eye has the added refinement of a variable focus lens.

With the evolution of increasingly specialized and complicated receptors attuned to light waves, there developed the ability to respond to small differences in the bright-

ness and shape of objects. Color vision and the ability to perceive the distance and depth of objects also emerged.

A somewhat similar trend was followed in the evolution of our other senses. At first there was no specialized organ for reception, then a crude specialized organ emerged. Gradually this receptor became more complex and organisms responded to increasingly intricate details of their environment.

12

Human Hand Compared with That of a Gorilla

(From Révész, G., Die Formenwelt des Tastsinnes. *The Hague: Nijhoff, vol. 1, p. 112. Photo courtesy of Longmans Green, publishers of the English translation,* Psychology and Art of the Blind.)

Effectors

Our effector organs, both glandular and muscular, also evolved from simple beginnings in lower animals. Of special interest to us here are the organs for locomotion and manipulation — those organs which enable us to move about in and change our environment.

In animals a little higher than ameba we find cilia and whiplike appendages which have a propelling function. Fins, wings, arms and legs serve a similar locomotor function in still higher organisms. It is of great significance that man is the only organism whose arms and hands are completely free from the needs of locomotion. They have become specialized for manipulation.

Animals lower than ourselves manipulate in many ways, with cilia, beak, mouth, feet, tail, and forepaws. We manipulate with mouth, feet, and hands. Evolution of our hand as a manipulative organ is of especial significance, for it gives us the ability to make and control fire, to invent and use tools and weapons and, above all, to pass on to others the fruits of our experience in the form of written records. Indeed the skill displayed by the human hand, controlled by a competent nervous system, is far beyond that of any other organism, including even the higher apes. Man's thumb is largely responsible for this. The ape's thumb, as shown in Figure 12, is very small and, for the most part, a passive member of the hand. In man, however, the thumb is relatively large. At the same time, it is capable of active movement in opposition to the hand as a whole and to each of the fingers separately. This great flexibility of the human hand may be related to the fact that our remote ancestors assumed an upright posture, thus completely freeing their hands from locomotor duties.

With assumption of an upright posture and development of manual dexterity came relative freedom of the mouth from crude manipulative duties. Structures of the throat and mouth were free to evolve into specialized effector organs, which, combined with a complex brain, led to the origin of speech.

In every such effector development as we have sketched, receptor and neural evolution was a necessary aspect. Receptors, effectors and neural mechanisms have always developed in close association. Development of one would actually have very little significance without concomitant development of the others.

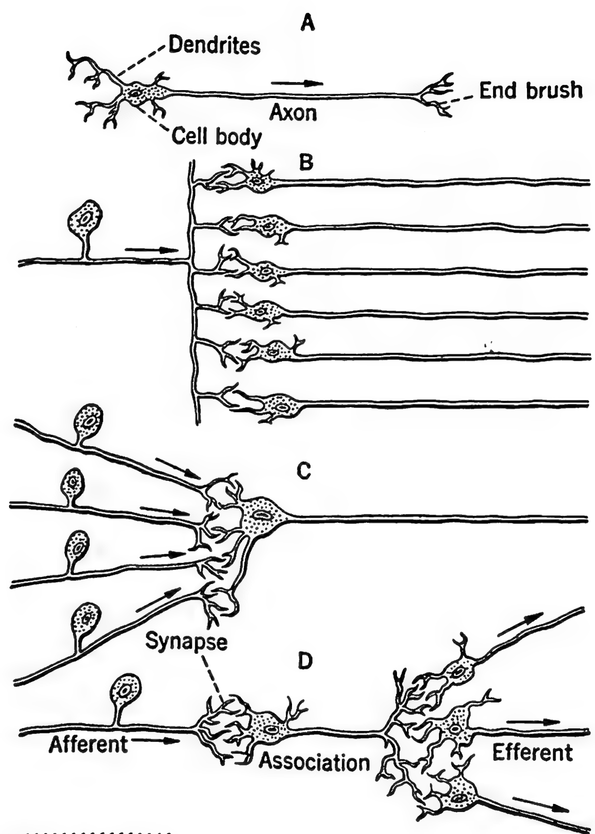
Nervous mechanisms

Our nervous system also had extremely simple beginnings. At first, as in ameba, there was no nervous system. Conduction occurred in the protoplasm, but it was diffuse — spread out in every direction. Movements precisely related to the nature of stimulation were impossible. Later on, muscles sensitive to direct stimulation made their appearance. There was no nervous system, but application of a strong stimulus to a muscle caused it to contract. Still later there developed small fibers which ran from receptors to muscles. Now the muscle did not have to be stimulated directly. Stimulating the receptor was sufficient to arouse muscular activity.

In some elementary nervous systems the fiber from each receptor runs into a network of fibers — not to the muscle directly. The muscle is connected with the nerve net. Stimulation of any receptor is thus likely to arouse a diffuse instead of a precise response. Because impulses run indiscriminately in all directions, every muscle connected with the net is moved.

Such indiscriminate conduction is not characteristic of higher nervous systems. Specific responses, like withdrawal of the hand from fire, are typical. Responses thus appropriate to the nature of stimulation first appear in animals having what is known as a "synaptic" nervous system. In this system, of which our own is a highly complicated form, there are relatively discrete nervous units known as *neurons.* Each neuron has a cell body and nerve fibers. Conduction through the neuron is normally in only one direction — from the *dendrites,* through the cell body, and along the *axon.* Figure 13 shows, schematically, the structure of some neurons. It also illustrates some neural junctions. The junctions where nerve impulses pass from one neuron to another are known as *synapses,* hence the term *synaptic nervous system.*

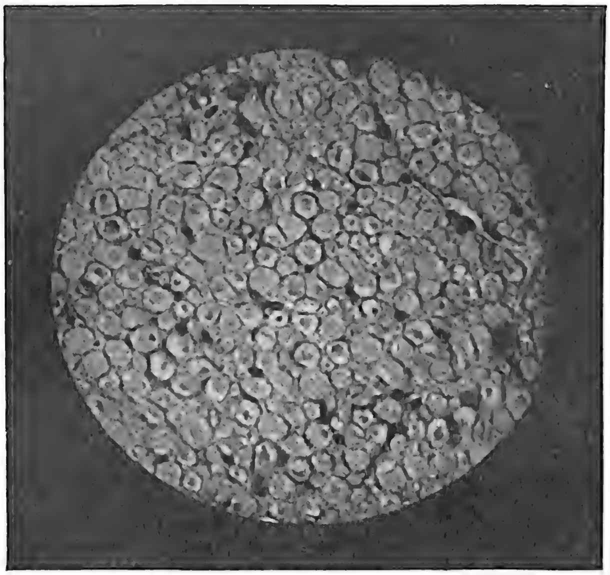
Synapses slow down the passage of nerve impulses from one neuron to another and often block passage of an impulse completely. Thus impulses from one neuron may terminate at the synapse or they may be shunted into certain channels and not into others. Interaction between neurons is possible at synapses and here the impulses of several neurons may combine to block



13

Some Neurons and Junctions

A shows the structure of a typical efferent (or motor) neuron. In B *impulses are represented as coming along an afferent (sensory) axon and into a synaptic junction involving several efferent neurons. The end brushes, which terminate in a muscle or gland, are not shown.* C *illustrates several afferent neurons converging upon a single efferent neuron. In* D *an association neuron is shown in synaptic conjunction with an afferent and several efferent neurons.*



14

Cross-Section of a Nerve

Each nerve fiber is seen, in cross-section, as a dark spot surrounded by a white fatty tissue which provides insulation. (From "The Nervous System," courtesy of Encyclopaedia Britannica Films, Inc.)

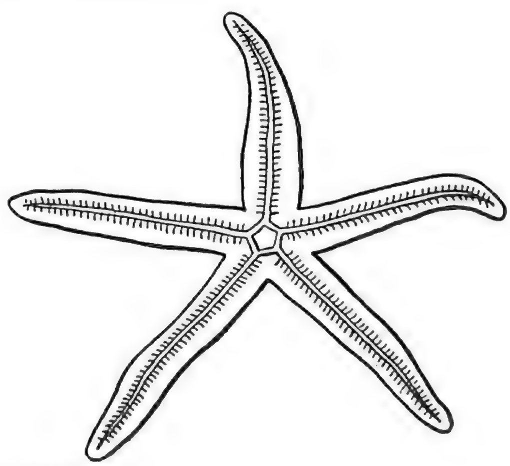
(inhibit) or to aid (facilitate) further transmission. It is because we possess this type of nervous system that we do not, like the jelly fish, have to respond all over when stimulated. Impulses follow pathways which are more or less specific, allowing us to make partial responses. The nerves are such specific pathways. Each nerve, as illustrated in Figure 14, is a bundle of insulated fibers very much resembling a cable.

Central nervous mechanisms

After development of neural links between receptors and effectors, and of relatively discrete nerve units, the next important step was development of a central "switchboard" to control the direction of incoming and outgoing impulses. Without some such integrating mechanism, each part of the body would act in complete independence of other parts.

One of the simplest central nervous mechanisms is seen in the starfish. This animal, as illustrated in Figure 15, has a central nerve ring which links together the nerves going to each of its five rays. When the starfish is turned on its back, the rays work together until the animal rights itself. Nice co-ordination is displayed, each ray playing its proper part at the right time. The significance of the nerve ring in this effectively co-ordinated readjustment is shown by an experiment in which the ring was cut.[2] When it was cut in only one place, a certain degree of bodily inco-ordination became evident. But when the ring was severed in two opposite places, the animal acted in such an inco-ordinated way as actually to pull itself apart. The nerve ring makes it possible for the reaction of a particular ray to be regulated by what other rays are doing.

It is a long way from the simple nerve ring of the starfish to the highly complex central nervous systems found in the vertebrates (the animals ranging from fish to man). Nevertheless, each of these systems is



15

The Nervous System of a Starfish

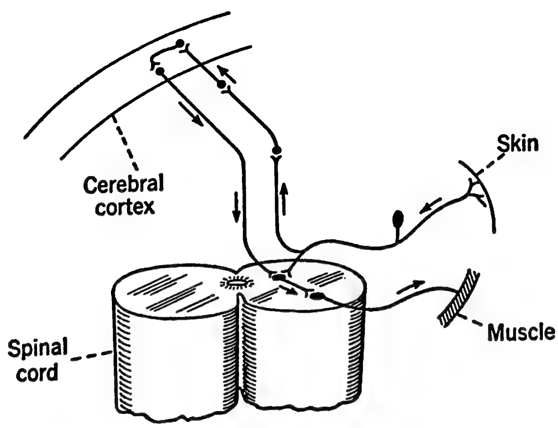
The central ring, which co-ordinates activities of the separate rays, is the brain of the starfish.

designed to serve the same basic function — integration of subordinate structures and functions. One interesting general development, from lower animals to the vertebrates, has been a shifting of control to the head, culminating in the vertebrate brain.

The central nervous system of all vertebrates has a somewhat similar pattern, but a pattern which becomes greatly elaborated as the human level is approached. Its basic integrating structures are illustrated in Figure 16.

Note that impulses coming from the skin enter the spinal cord over afferent neurons and, at the same level, make synaptic connections with association and efferent neurons. When this circuit (the reflex arc) is completed, the muscles respond. Thus a prick causes the hand to be withdrawn. But this is the simplest possible integration. Observe that, as impulses come in over the afferent neuron, they not only travel around the arc, but also ascend the cord. At the upper end of the cord, in lower brain centers, other circuits may be made, carrying the impulses back to efferent neurons at the level of stimulation. These circuits, which occur at the levels where synaptic connections appear, are not illustrated. But our diagram does show a circuit through the upper level of the brain (cerebral cortex). Here we see that impulses reaching the cortex may be switched over to fibers which descend the cord, causing them to return to the motor neurons and out to the muscles. Actually there are many such ascending and descending fibers and the complexity of connections at the level of the cerebral cortex, even in a lower mammal, defies adequate description.

The simplest integration is in the spinal cord, at the level of stimulation. Such integrations are involved in reflex acts, as where a limb is withdrawn almost immediately in response to painful stimuli. Integrations of still greater complexity, which require such upper circuits as we have illustrated, are involved when learned acts are carried out. Circuits like these (see Figure 26, p. 57) underlie our own learned acts, as well as our awareness of ourselves and of the world about us.



16

A Schematic Representation of Some Neural Circuits in the Brain and Spinal Cord

Connections on only one side are shown. This diagram, which is of course simplified to an extreme degree, shows the reflex arc, an ascending and a descending pathway, and upper connections. For further explanation, see text. (After Herrick.)

Evolution of the brain

The ultimate control of behavior depends upon integrating mechanisms in the brain, those mechanisms which complete the upper circuits mentioned in our preceding illustration. Worms and other relatively simple animals have brains. The nerve ring of the starfish is this animal's brain. Higher invertebrates, including earthworms, have groupings of nerve cells (ganglia) at the head end. These ganglionic brains are precursors of vertebrate brains.

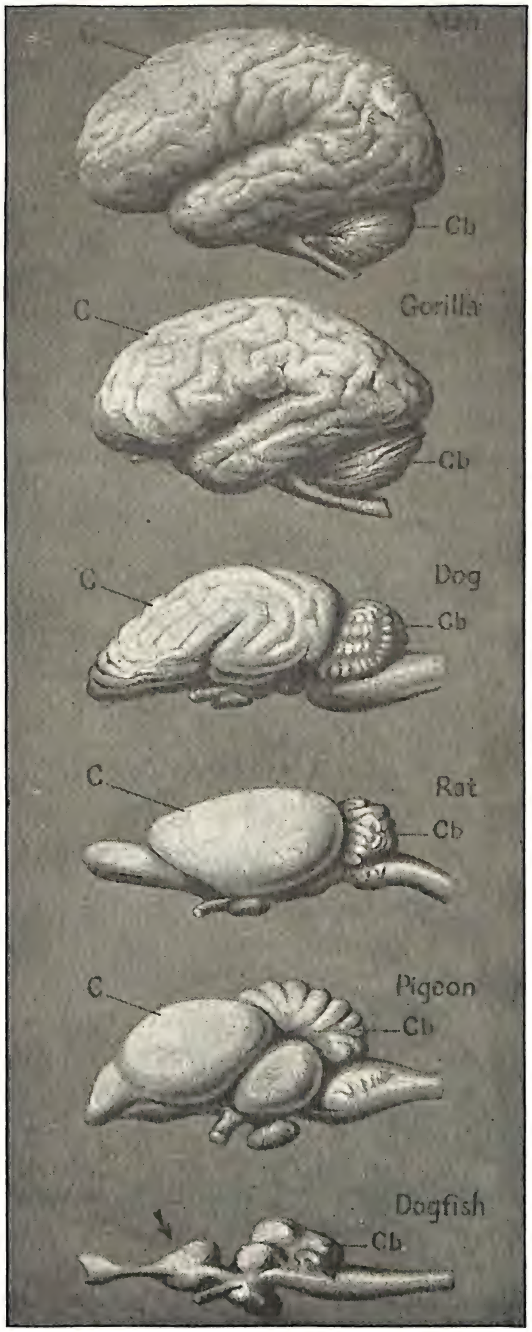
The emergence of the human brain is most clearly foreshadowed in the brains of vertebrates. Some of these lower brains, as well as man's, are shown in Figure 17, each drawn from the same position.

One of the most obvious developments is an increase in the size of the brain, but

man's brain is by no means the largest. A typical human brain weighs about three pounds, which is quite heavy as compared with that of most animals; but an elephant's brain weighs ten pounds and a whale's fourteen pounds. Since man is much more intelligent than an elephant or a whale, something other than sheer brain size holds the key to intelligence. Actually the ratio of brain weight to body weight gives a much better suggestion of the relation between brain size and intelligence than does brain weight alone. This ratio is 1/50 for man, 1/500 for the elephant, and 1/10,000 for the whale.[3]

Consider, for a moment, what the brain does. Among other things it integrates all of the receptors and body parts. A tremendous body makes heavy demands upon the brain. Every receptor and muscle must have neural connections adequate for its integration with the rest of the body. This means that, as bodies grew larger, more brain tissue was needed for mere sensory and motor integrations, including control of such elementary functions as respiration and digestion. A brain dedicated entirely to such elementary duties, no matter how large, is no more advantageous than a small one serving the same functions in a smaller animal. Behavior controlled by the larger brain is as simple and routine as that controlled by the smaller one. The larger the brain in proportion to body weight, however, the larger the amount of tissue not reserved for routine sensory, motor, and physiological activities. There is nervous tissue to spare, to be modified by what happens to the organism during its lifetime.

Animals having little or no "extra" brain tissue are to a very great extent creatures of



17 **The Brain from Fish to Man**

These brains were drawn to the same length so that adequate detail could appear in the smaller ones. An idea of their relative size can be gained from their approximate weights, in grams: man, 1500; gorilla, 400; dog, 120; rat, 2; pigeon, 2.2; dogfish, 3. C *is the cerebrum. Since the dogfish has no cerebrum, an arrow indicates comparable structures.* Cb *is the cerebellum. Note the recession of the smell brain, so prominent to the extreme left of the lower brains. (Redrawn from various sources.)*

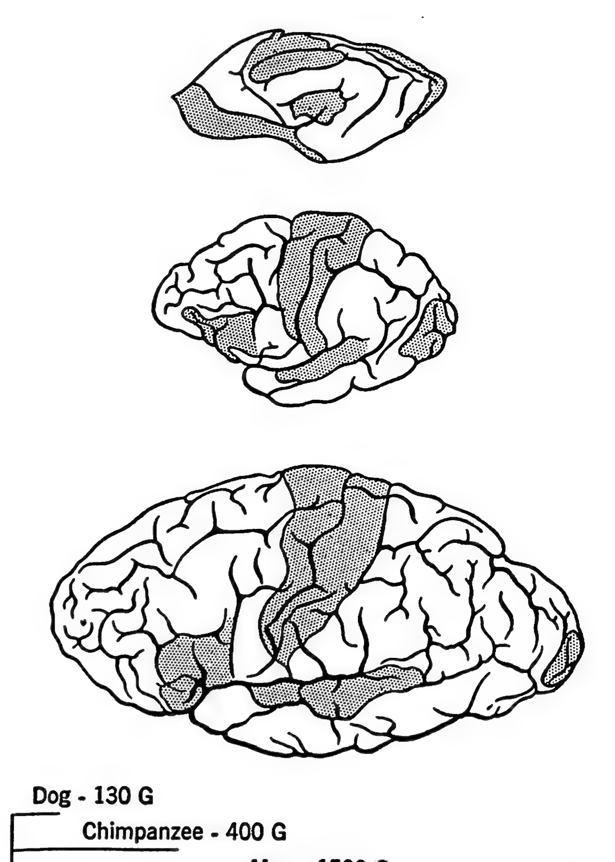
instinct. That is to say, they are dominated by predetermined receptor-effector connections. Their behavior is to a large degree unlearned, determined more by inheritance than by individual experience. Indeed they exhibit a relatively low degree of learning ability. But to the extent that neurons not already assigned to specific sensory and motor functions are present, we find increased evidence of psychological processes like memory and reasoning.

The ratio of brain weight to spinal cord weight is even more revealing than the ratio of brain weight to body weight. A large body not only requires a large brain, but it also needs a large spinal cord. The spinal cord has routine duties, many of which are controlled from above. It increases in size as the brain becomes larger. In the lower vertebrates, however, the spinal cord is as large as the brain itself. Then, during the course of evolution, the brain becomes increasingly larger than the cord. This suggests that it is assuming functions in addition to the routine duties also served by the spinal cord. When the level of the apes is reached, the brain has become fifteen times as heavy as the spinal cord. In us, it is fifty-five times as heavy.[4]

The simpler brain structures, which make up almost the entire brain of fishes, birds, reptiles, and amphibians, are often referred to as the *old brain.* These structures, set aside for simple sensory and motor functions, were retained in the brains of all higher animals, but superimposed upon them was a structure known as the *new brain,* or *cerebrum.* This first appeared as a small organ above the others, but it evolved until, in the mammals, it became the largest of all brain structures. Even *its* functions were at first almost completely routine. As it increased in complexity, however, the cerebrum, although it still had sensory and motor duties, developed large *association areas,* whose neurons were assigned the functions of handling complex interrelationships between other parts. Association areas, and parts having more specific functions, developed in the outermost layers (gray matter) of the cerebrum. These layers comprise the *cerebral cortex.*

As the cerebral cortex developed, the outer surface of the cerebrum, at first smooth, took on the wrinkled appearance shown in the higher brains of Figure 17. These wrinkles mark places where the surface folded inward (invaginated), making possible an increased number of association neurons within a restricted space.

Cortical association areas are quite exten-



18 **The Association Areas of Man, Chimpanzee, and Dog**

The shaded areas are specialized for sensory or motor functions. Association areas are shown as white. (After Cambell and Bartelmez.)

sive in higher mammals, and especially in man. The dog and the chimpanzee, whose brains are compared with man's in Figure 18, have large association areas. But the proportion of their brains that is reserved for associative, as compared with sensory and motor functions, is relatively small.

It is the plasticity of his association tissues that renders man's behavior so modifiable — making him more a creature of habit, based on individual experience, than of instinct. This same modifiability also underlies his great inventiveness, his language, and the products of his thought. It allows him to respond not only in terms of the present and the past, but in terms of the anticipated future. His ability to adjust to changing circumstances is far greater than that of any other organism. Of all organisms, man alone may be guided by ideals. It is not surprising, therefore, that one of our greatest neurologists referred to man's brain as "the master of destiny." [5]

THE NERVE IMPULSE

We have seen that when stimuli impinge upon receptors attuned to them, they initiate receptor activities which, in turn, discharge energy in the attached nerve fibers. The energy which carries the impulse along is in the nerve fiber, not in the stimulus. All that the stimulus, or the receptor activity, does is to ignite, as it were, the energy already present in the nerve fiber. Indeed a nerve impulse is a succession of disturbances somewhat analogous to the successive explosions which run along a fuse when one end is lit. In the nerve fiber, these "explosions" are electrochemical disturbances. After an impulse has reached the end of the first nerve fiber, further transmission is determined by conditions at the synapse. If the impulse bridges the synapse, it then traverses association or motor neurons, the energy discharged being, in each case, that in the activated nerve fiber itself. We find no nerve energy that does not reside in the neurons themselves. Even the most complex activities of the cerebral cortex are no more than the integrated effects of discharges of energy in association neurons. Therefore, anybody who speaks of "dammed up" nervous energy or of "reserves of nervous energy" is speaking figuratively.

We see, then, that the nervous system provides the energy as well as the pathways for transmission of nerve impulses. Psychological functions are of course dependent upon the complexity of the system of nervous communication, but they also depend upon the nature of the nerve impulse.

The doctrine of specific nerve energies

The nerve fibers from each kind of receptor were once thought to carry different kinds of nerve impulses. Fibers from the eye, for example, were supposed to carry "visual impulses," those from the ear "auditory impulses," and so on. It was said that if the optic nerves could be detached from the eye and attached to the ears, stimulation of the ears would arouse impulses of the "visual type" and would elicit seeing instead of hearing. Similarly, attaching the auditory nerves to the eyes would cause us to hear with our eyes. To put it another way, we would "see thunder and hear lightning." This experiment was of course never carried out, but the suggestion of it serves to illustrate what was meant by the concept of "specific nerve energies."

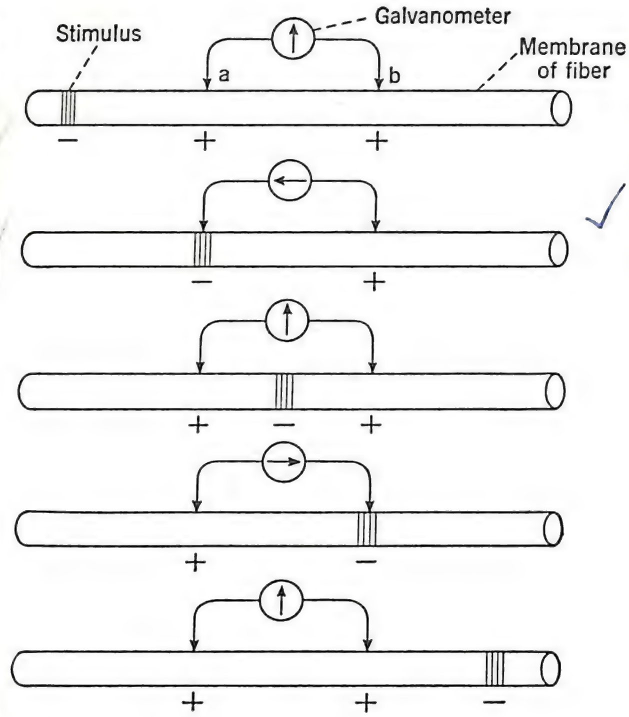
Today, as a result of research on the nerve impulse, we know that impulses carried by all nerve fibers, both sensory and motor, are essentially alike. Fibers from the eyes do not carry impulses which are different from those carried by fibers connected with the ears, or even with the muscles.

If all fibers carry similar impulses, how can we account for the differences in sensory experience? If visual and auditory fibers carry similar impulses, why do we see when

the eye is stimulated and hear when the ear is stimulated? The answer, as we shall observe in more detail when vision and hearing are discussed, is that impulses from the eye and ear, although alike, go to different regions of the cerebral cortex. What seemed like "specificity of energy" was due to "specificity of termination." Indeed, the switching of visual and auditory nerves, if possible, would do what the specific nerve energy theorists said it would do — make us "see with our ears" and "hear with our eyes" — but not because the energies are different. The impulses which go to the visual region of the cerebral cortex would now be coming from the ears and those which go to the auditory region would now be coming from the eyes.

Although nerve impulses are essentially alike, regardless of their origin or point of termination, their frequency increases as the intensity of stimulation increases. In other words, there are more of them. This variation underlies the intensity of sensory experience and the strength of motor activity.

In order that what has been said may be more fully understood, we shall now examine the nature of the nerve impulse at closer range, giving some attention, also, to how the impulse is measured.



19

The Nerve Impulse

We see here a galvanometer making two contacts with a nerve fiber. The stimulus sets off a wave of negative electrical potential which passes along the membrane and deflects the galvanometer as illustrated. With suitable instruments such deflections may be recorded on photographic film.

The nature of the nerve impulse

The nerve impulse, when recorded galvanometrically, as illustrated in Figure 19, is indicated by a change in electrical potential. Each successive impulse traveling along a given fiber has the same potential, regardless of the nature of the activating stimulus or the intensity of stimulation. If the fiber responds at all, in other words, it responds completely. This is known as the *all-or-nothing* principle.

After a neuron has responded to stimulation, there is a brief interval during which it cannot again be activated, no matter how intense the stimulus. This interval is the *absolute refractory period.* Its shortest duration is about one thousandth of a second. After this brief period, there follows the *relative refractory period,* during which the nerve fiber may be activated, but only by a stronger than normal stimulus.

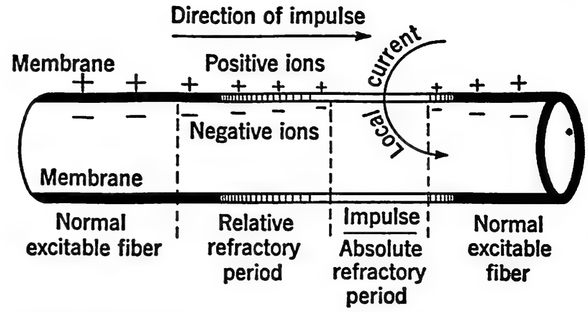
A stronger than normal stimulus may thus activate before the neuron has recovered normal excitability. Within certain limits, moreover, the more intense the stimulus, the earlier in the relative refractory phase it can activate a fiber. Thus a strong stimulus may activate the fiber at briefer intervals than a weaker one, causing more impulses per second to travel along it. The stronger

the stimulus, in other words, the greater the *frequency* of nerve discharge.

Thus each impulse activated by a strong stimulus has the same potential as one activated by a weaker stimulus (the all-or-nothing principle); but there are more impulses per second with the stronger than with the weaker stimulus (the frequency principle). In a single nerve fiber, therefore, the effect of differences in stimulus intensity is the arousal, not of different kinds or sizes of impulses, but of more frequent impulses.

The fact that increasing intensity of stimulation leads to more frequent nerve discharges, as well as to a greater intensity of experience and of muscular contraction, naturally suggests that the intensity of sensory experience and of muscular activity depend upon the frequency of nerve impulses. When a single fiber is involved, as in the experiments described here, an increase in intensity of stimulation can produce only a change in frequency of discharge. Under normal circumstances, however, where bundles of fibers (nerves) are stimulated, a more intense stimulus activates more fibers. Thus increasing the intensity of stimulation does two things neurologically; it (1) increases the frequency of response in each fiber and (2) activates more fibers. The effect, in each instance, is that more impulses reach the synapse, muscle, cerebral cortex, or whatever the terminal point happens to be.

According to the *membrane theory* of nervous transmission, each nerve fiber has a semipermeable membrane (Figure 20) with positive ions on the outside and negative ions on the inside. While in this state, the fiber is said to be *polarized.* Each part is, in effect, a microscopic battery with its negative and positive poles. When the fiber is stimulated, the membrane in that region becomes more permeable, letting the positive and negative ions unite. A wave of negative electrical potential thus sweeps the fiber. This *action current* or *propagated* *disturbance* is the nerve impulse. Its speed of transmission differs for fibers of different thickness, but averages four miles per minute.



20 **Excitation and Conduction in a Nerve Fiber According to the Membrane Theory**

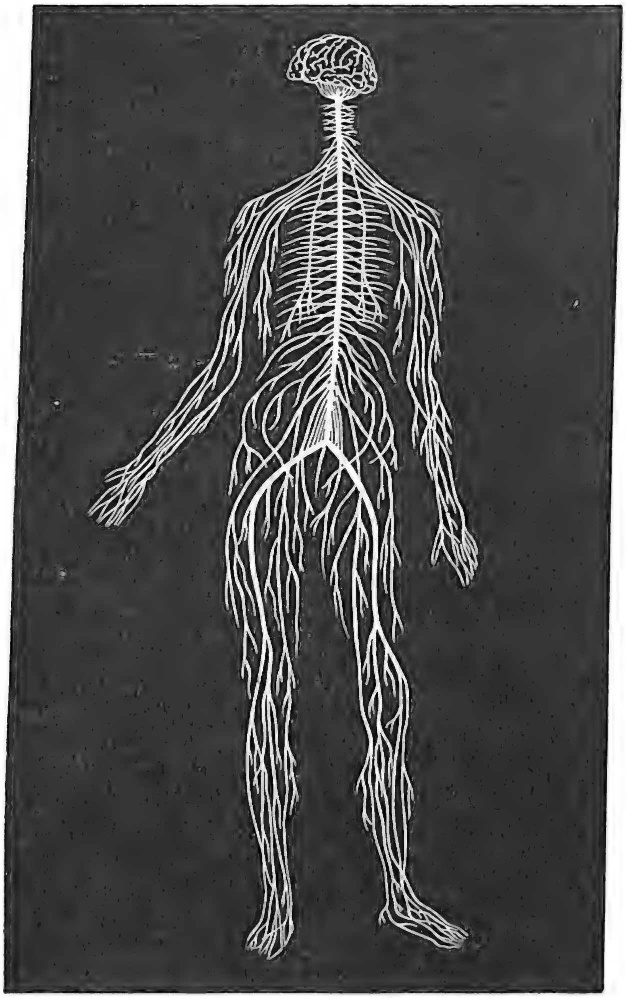
A semipermeable membrane is represented as polarized with positive ions on the outside and negative ions within. Stimulation renders the membrane permeable. Ions then pass through it and neutralize each other. This depolarizes the adjacent region, and so the disturbance is propagated along the fiber. Recovery of excitability is also represented. (Reproduced by permission from Foundations of Psychology, *by Boring, E. G., H. S. Langfeld, and H. P. Weld, published by John Wiley and Sons, Inc., 1948, p. 28.)*

Shortly after the impulse passes a region, the original position of the ions is re-established. The fiber in this region is then ready to react again and another impulse may traverse it.

THE HUMAN NERVOUS SYSTEM

Our nervous system is, in reality, a community of closely integrated systems. Its chief over-all divisions are seen in Figure 21, which gives a much-simplified idea of how we would look if stripped of all but our nervous mechanisms.

The spinal cord and brain are together referred to as the *central nervous system.* The spinal cord integrates the incoming and outgoing impulses involved in reflex activities and it also provides channels for ascend-



21

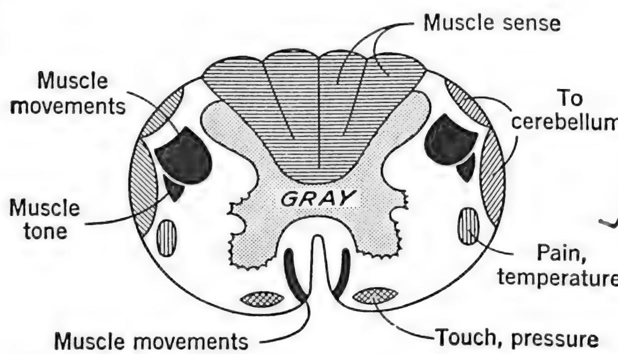
The Human Nervous System

This schematic overall view shows the general arrangement of the human nervous system. (From The Scientific American, *1948, 179, p. 15.)*

ing and descending nerve impulses. Such ascending (sensory) and descending (motor) tracts have already been illustrated (p. 48). Figure 22 shows some of the longer tracts as they would appear in a cross-section of the spinal cord. Various brain mechanisms, to be examined more closely later, serve to integrate incoming and outgoing impulses. They also provide the neural basis of higher psychological processes, such as remembering and thinking.

Radiating from the central nervous system are the various nerves known, *in toto*, as the *peripheral nervous system*. These are the nerves which, as we have seen, convey impulses into and out from the spinal cord and lower brain centers. Those connecting with the spinal cord are referred to as *spinal* and those connecting with the brain stem as *cranial* nerves. Impulses from the skin enter the spinal cord as illustrated in Figure 23. The muscles also contain receptors and when these contract or relax, afferent impulses like those from the skin also enter the spinal cord. Only the motor connection with the muscle is shown in the diagram. Our other senses are served by nerves (optic, auditory, etc.) running into the lower brain centers. Motor connections are present at all levels. Note that each spinal nerve has two attachments to the spinal cord, one (afferent) serving a sensory and the other (efferent) a motor function.

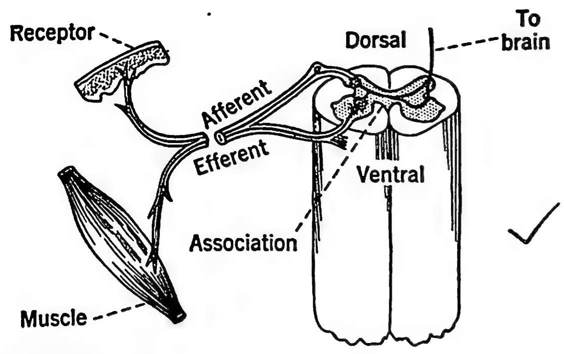
The internal organs such as the heart and lungs and the viscera (stomach, intestines, spleen, pancreas, etc.) are served by the



22

The Main Fiber Tracts of the Spinal Cord

Ascending (sensory) tracts are represented as shaded and descending (motor) tracts as black. The gray matter of the spinal cord contains association neurons. Outside of the gray matter, the unspecified regions of white matter contain short ascending and descending tracts. (From Carlson and Johnson's The Machinery of the Body. *University of Chicago Press, 1948, p. 431.)*

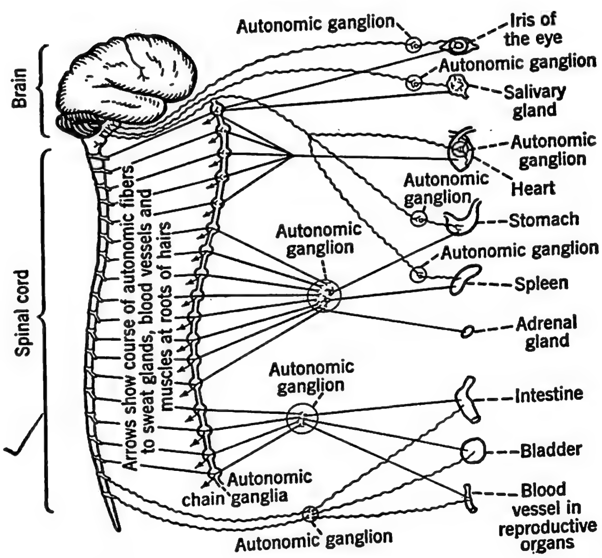


23 **Diagram Illustrating the Reflex-Arc System**

Impulses from receptors travel toward the spinal cord over afferent neurons of the spinal nerve. There they initiate impulses in the association neurons. These impulses in turn arouse efferent neurons along which impulses travel to the muscles. Nerve fibers also carry impulses toward the brain and from the brain down to various levels of the spinal cord. Note that cell bodies of afferent neurons are outside of, and cell bodies of association and motor neurons within, the spinal cord. These connections are in the gray matter. Note, too, that afferent fibers connect with the back or dorsal and efferent fibers with the front or ventral portion of the spinal cord. (Redrawn from "The Nervous System," courtesy of Encyclopaedia Britannica Films, Inc.)

autonomic nervous system, shown schematically in Figure 24. This system has two major divisions known, respectively, as the *sympathetic* and *parasympathetic* systems. In our diagram, the straight lines show sympathetic connections. Observe that these links with vital organs, glands, and other internal structures are made with the spinal cord through an intermediate vertical chain of ganglia (nerve cell groupings). They comprise the central part of the autonomic nervous system. Above and below these sympathetic connections are others, shown as wavy lines. These are parasympathetic structures. Many of the visceral and other structures shown in the diagram are seen to have dual connections, one with the sympathetic and the other with the parasympathetic system. The two systems are functionally antagonistic. For example, the sympathetic system accelerates heart action while the parasympathetic slows it down. On the other hand, the parasympathetic accelerates stomach activity, which is checked by the sympathetic. We see, then, not only that the two divisions of the autonomic nervous system work in opposition, but that the division which accelerates the activity of one internal organ may check the activity of another. The autonomic nervous system will be dealt with in greater detail when we consider emotion, a psychological process which, to a large extent, is dependent upon control of behavior by the sympathetic nervous system.

The autonomic nervous system is, by definition, a motor system. Nevertheless, each of the organs whose activity is controlled



24 **Schematic Representation of the Autonomic Nervous System**

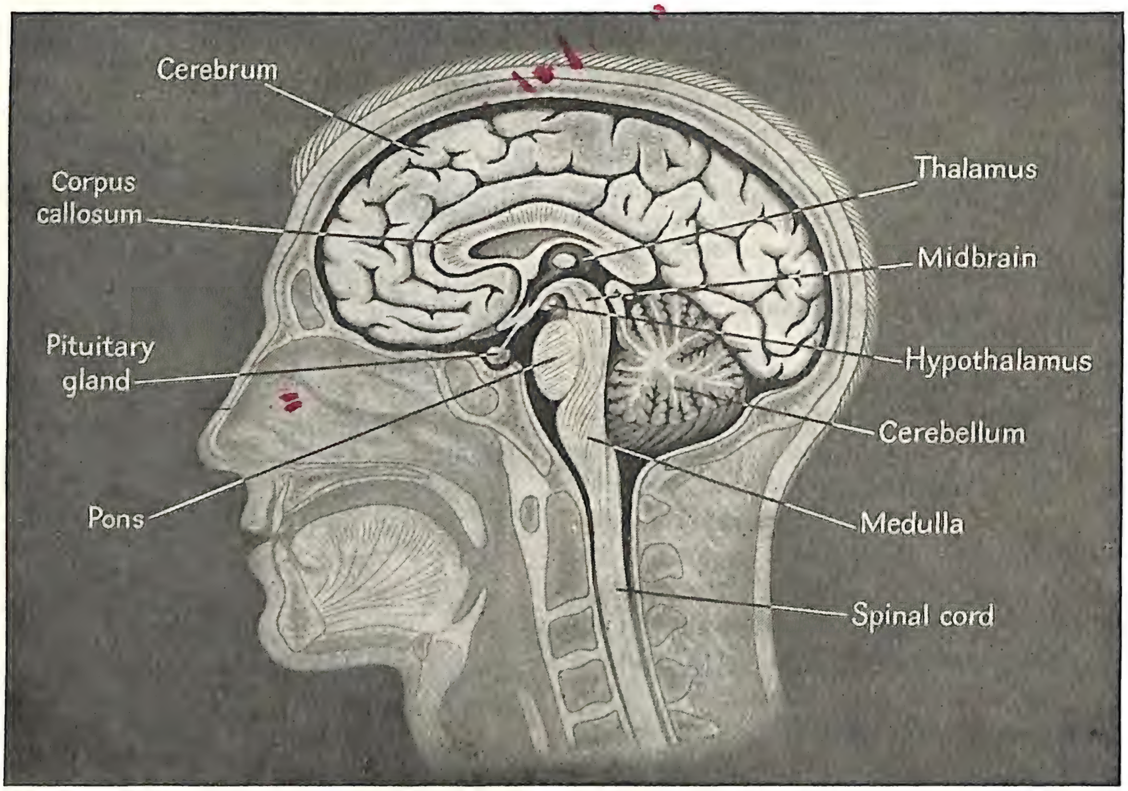
Compare this figure with Figure 170. Here, the wavy lines represent the parasympathetic and the straight lines the sympathetic division of the autonomic nervous system. (From Warren, H. C., and L. Carmichael, Fundamentals of Human Psychology. *Boston: Houghton Mifflin, 1930, p. 33.)*

by this system also has afferent connections with the spinal cord and brain. Impulses traveling to the brain over these pathways underlie whatever awareness we may have of what is taking place in the visceral and other internal organs. Feelings of nausea, internal cramps, and hunger exemplify experiences dependent upon such afferent connections.

We are now prepared to examine the human brain more closely, paying especial attention to the psychological significance of its major structural divisions.

THE HUMAN BRAIN

Our chief brain structures are illustrated in Figure 25, which shows how they would look if the head were split midway between the ears. The *cerebrum* consists of the *cerebral hemispheres,* joined by a thick sheet of nerve fibers, the *corpus callosum.* Toward the back, and underneath the cerebrum is the *cerebellum,* a structure intimately involved in activities which, like walking, swimming, and talking, require the co-ordination of many muscles. The brain stem, comprising several important integrating mechanisms, begins at the corpus callosum and is continuous, at its lower end, with the spinal cord. It contains various integrating mechanisms, of which only the thalamus, hypothalamus, midbrain, pons and medulla are shown. Another structure involved in the control of co-ordinated motor activities, is the corpus striatum. It lies above the thala-



25

Cross-Section of the Human Brain

This view shows the right cerebral hemisphere and its position in the skull. It is connected with the left cerebral hemisphere through the corpus callosum. The lobes of the cerebellum are connected through the pons.

mus and is to be seen in Figure 29, p. 60. Of the structures of the brain stem only two, the thalamus and hypothalamus, are of sufficiently direct psychological significance to warrant further attention here.

The *thalamus* is an elaborate switchboard mechanism whose chief function is to route incoming sensory impulses to appropriate regions of the cerebral cortex. Impulses originating in the skin are sent to one part of the cortex, those from the ears to another part, and so on.

Many sensory-motor connections are made in the thalamus. These underlie much of our automatic activity, like walking, to which we do not have to give our attention.

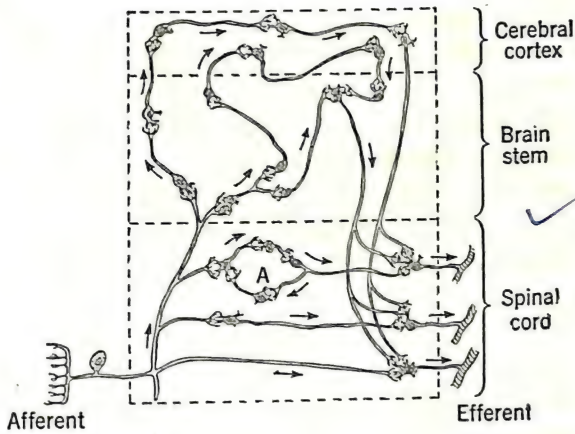
The thalamus also receives impulses from the cortex. These impulses have an inhibitory effect upon automatic activities. When the cortex is removed, or injured, automatic reactions are often exaggerated.

In lower mammals, and to a certain extent in man, the thalamus makes possible a crude sensitivity to certain kinds of stimuli. A simple form of learning also occurs on a thalamic level, as shown by experiments with dogs deprived of their cerebrum.[6]

Within the *hypothalamus,* beneath the thalamus and below which the pituitary gland may be seen, are centers for control of emotional behavior and wakefulness, as well as several other processes of less interest to psychologists. The role of the hypothalamus in emotion will be considered when we discuss emotional behavior.

INTERCONNECTING CIRCUITS

Some idea of the interconnections of the various brain centers and the spinal cord is conveyed by Figure 26. Here we see that impulses traveling upward from an afferent fiber in the spinal cord may connect more or less directly with an efferent neuron and muscle at the same level, or may make increasingly circuitous connections at upper levels of the cord, brain stem, and cerebral



26 **Some Interconnecting Circuits**

Note the reverberating circuit at A. (After Ranson and Clark's Anatomy of the Nervous System, *Saunders, 1947, p. 98, as modified from Bayliss.)*

cortex. Generally speaking, the lower the level at which the circuit between receptor and effector is completed, the more stereotyped the behavior. Lower circuits produce automatic reflex behavior. The uppermost circuits produce behavior that: (1) is learned, (2) is possibly associated with awareness, and (3) may be under voluntary control.

A type of neural circuit which plays an important role in all psychological activities is illustrated as occurring at *A* in the spinal cord. Similar circuits of almost inconceivable complexity occur within the billions of neurons which make up our brain. First let us look at this simple circuit. Note that impulses entering such a circuit may travel around (reverberate) within it, as well as pass on to the efferent fiber. Thus, impulses started by some stimulus may continue to excite the efferent neurons after the stimulus itself has gone. Self-exciting circuits of the cerebral cortex seem to underlie the persistence of desires, fears, and thoughts after the occasion for their arousal has passed.

Muscles themselves are self-exciting, for each muscle has not only motor end-plates (where the efferent impulses activate it) but

also receptors embedded within it. These are movement (kinesthetic) receptors. Such receptors are stimulated whenever the muscle moves. Movement sets up afferent impulses which travel back to the spinal cord and brain. These impulses may then return to the muscle itself. Thus the stimulus which originally arouses muscular activity is not necessary for the continuance of that activity — the activity provides its own stimulation. But not only that — the stimulation changes in such a manner from moment to moment as to give signals which regulate further activity. Somewhat as a governor regulates the speed of a motor or the thermostat regulates temperature, the "feedback" circuits in the nervous system keep our muscles functioning in the co-ordinations required for adequate adjustment.

A mathematician who has studied the similarity between neural feedback mechanisms and comparable mechanisms in electronic calculators, has the following to say about how such mechanisms control a simple act like picking up a pencil.

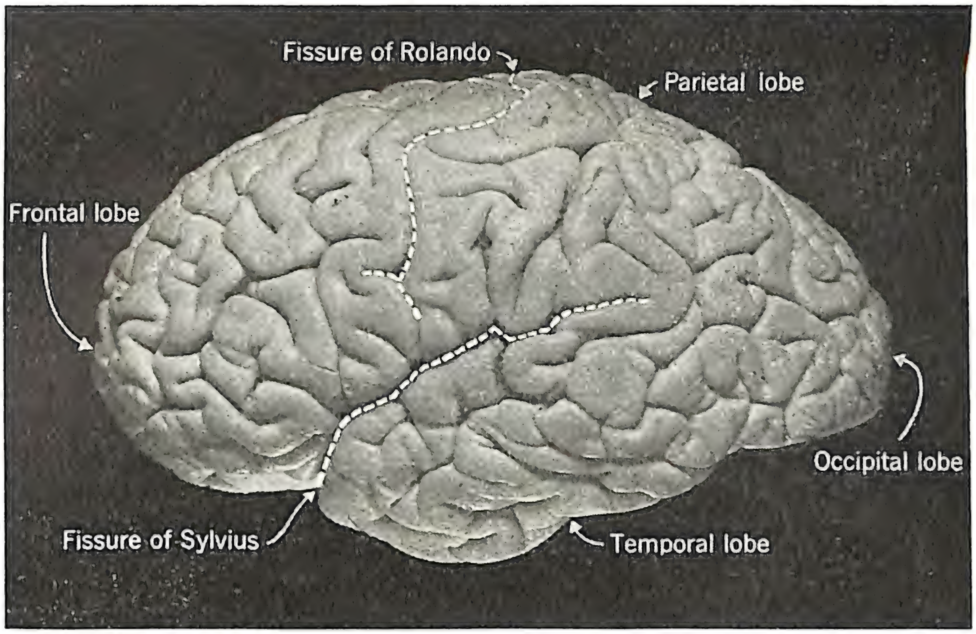
> Suppose that I pick up a pencil. To do this I have to move certain muscles. Only an expert anatomist knows what all these muscles are, and even an anatomist could hardly perform the act by a conscious exertion of the will to contract each muscle concerned in succession. Actually, what we will is not to move individual muscles but to pick up the pencil. Once we have determined on this, the motion of the arm and hand proceeds in such a way that we may say that the amount by which the pencil is not yet picked up is decreased at each stage. This part of the action is not in full consciousness.
>
> To perform an action in such a manner, there must be a report to the nervous system, conscious or unconscious, of the amount by which we have failed to pick up the pencil at each instant. The report may be visual, at least in part, but it is more generally kinesthetic, or to use a term now in vogue, proprioceptive. If the proprioceptive sensations are wanting, and we do not replace them by a visual or other substitute, we are unable to perform the act of picking up the pencil and find ourselves in a state known as ataxia. On the other hand, an excessive feedback is likely to be just as serious a handicap. In the latter case, the muscles overshoot the mark and go into uncontrollable oscillations. This condition, often associated with injury to the cerebellum, is known as purpose tremor.
>
> Here, then, is a significant parallel between the workings of the nervous system and of certain machines. The feedback principle introduces an important new idea in nerve physiology. The central nervous system no longer appears to be a self-contained organ receiving signals from the sense and discharging into the muscles. On the contrary, some of its most characteristic activities are explainable only as circular processes, traveling from the nervous system into the muscles and re-entering the nervous system through the sense organs.[7]

THE HUMAN CEREBRAL CORTEX

We have seen that the cerebral cortex is an extremely complicated mechanism which makes possible all of our higher psychological processes and which also influences our simplest activities. The arrangement of its billions of neurons controls the directions followed by nerve impulses. But, in addition to this switchboard function, the cortical neurons become somehow altered by what has happened to them.* Thus we can recall, and even "rearrange," past events. The "rearrangement" takes place whenever we reason out the solutions to our problems in terms of past experience.

The major surface characteristics of the human cerebrum, photographed from the left, are shown in Figure 27. One long fis-

* It has been suggested that the retaining function of the nervous system is analogous to that of wire recording, for "the storage of information in the wire recorder modifies the wire at a molecular level but not within optically observable microscopic dimensions and information fed by such a wire to scanning circuits can reappear in its original form after a shut down of the apparatus when its circuits are later reactivated." (Hoagland, H., "Rhythmic Behavior of the Nervous System," *Science,* 1949, 109, p. 163.)



27

Photograph of the Human Brain as Seen from the Left

The coverings of the brain have been removed so that the cerebral cortex is exposed. (Photograph from Gardner's Neurology. *Philadelphia: Saunders, 1947, p. 11.)*

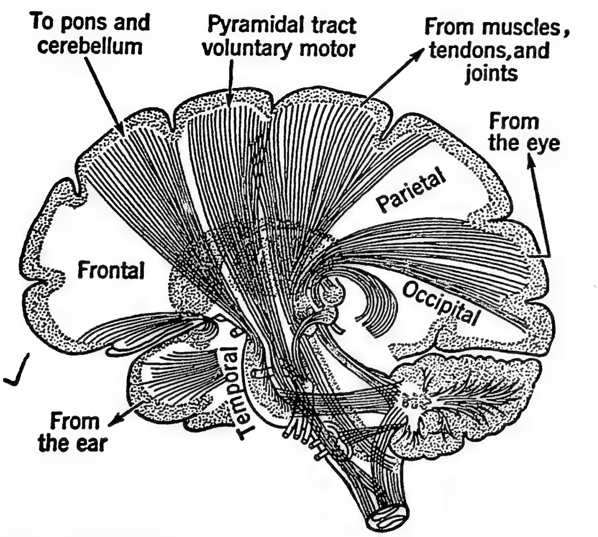
sure, the *fissure of Rolando,* runs from the top of the cerebrum downward at about the center. It divides the *frontal* from the *parietal* lobe. The other, known as the *fissure of Sylvius,* extends diagonally from the lower front part of the cerebrum. It separates the *temporal* from the *frontal* and *parietal* lobes. The *occipital* lobe is at the lower back of the cerebrum.

Running into these lobes, making connections like those schematically represented in Figure 26 (p. 57) are the sensory projection fibers shown in Figure 28. Motor pathways to the brain stem and spinal cord are also shown. Of these, the *pyramidal tracts* are voluntary motor pathways. They get their name from the fact that the cells of the cerebral cortex where they originate are shaped like pyramids. They are utilized every time we voluntarily move any part of our body. Each of the lobes is connected with the others by association paths like those pictured in Figure 29.

Cortical rhythms

The cerebral cortex exhibits certain rhythms which result from electrical discharges in its cells. These rhythms or "brain waves" are recorded with an instrument called the electroencephalograph, one type of which is shown in Figure 30. The electroencephalogram, or EEG, for short, may be recorded from any part of the scalp or brain surface. Records from the scalp have the same rhythmic patterns as those from the cortex itself, but very high amplification is required for recording them.

The most typical rhythm, averaging about ten oscillations per second, is obtained in darkness or with the eyes closed, and with "the mind at rest." This is the rhythm (al-



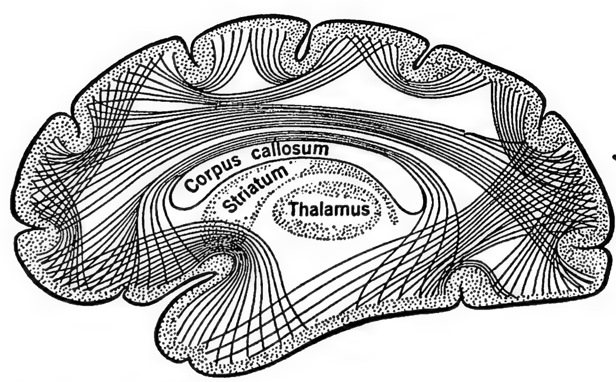
28 **Projection Paths of the Human Cerebrum**

The sensory projections begin in the thalamus. Here, impulses from the eyes are switched to the occipital, those from the ears to the temporal, and those from the muscles and skin to the somaesthetic region. Observe, at the bottom of the brain stem, that some motor fibers cross to the other side while some descend on the same side. (After Starr.)

pha) illustrated in Figure 31, A. It is most easily obtained from the occipital and parietal regions but it can be picked up almost anywhere on the scalp. When the eyes are opened, the alpha rhythm disappears, as shown in Figure 31, B.* This basic ten cycle rhythm is modified by a wide variety of conditions. It is reduced in amplitude and otherwise modified when the individual engages in motor, perceptual, and mental tasks, like gripping something with the hand, listening to a watch tick, or performing arithmetical calculations. When one falls asleep, the alpha rhythm is replaced by slow and irregular oscillations like those illustrated in Figure 31, C.

Recently a new EEG, superimposed upon the alpha rhythm, has been identified as a correlate of mental activity, like discriminating between tones, making decisions, and reasoning. These rhythms, designated "kappa waves," are shown in Figure 31, D. They are picked up most clearly near the outer corners of the eyes. Kappa waves are not especially evident during the learning process, but become pronounced when the individual tries to recall what he has learned, which is an essential aspect of thinking.[8]

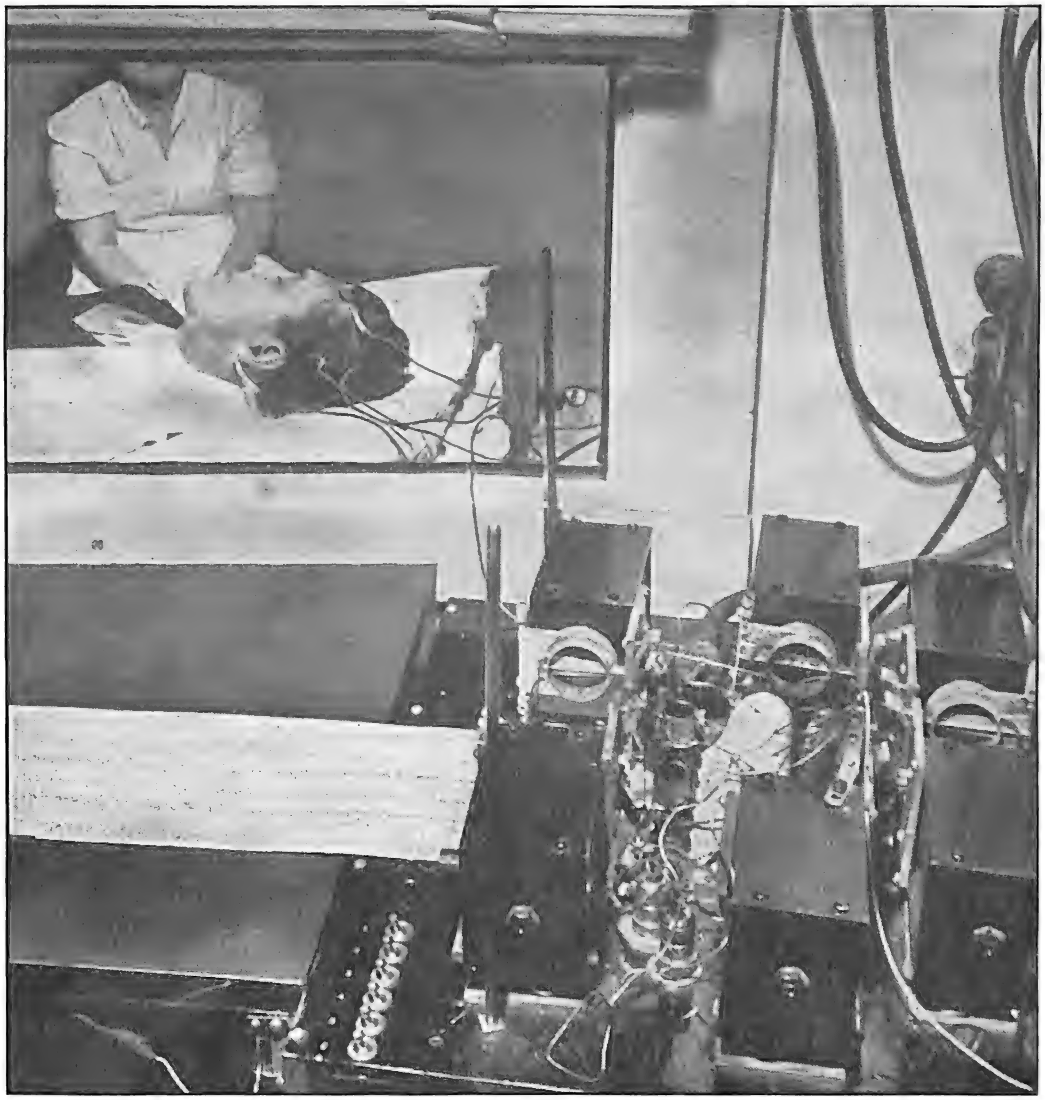
EEG's have proved useful in studying the electrical activities of the brain, whose periodic discharges are believed to depend a great deal upon reverberating circuits like those previously discussed. But these records of brain activity have also served two very practical ends. One is the locating of



29 **Association Paths of the Human Cerebrum**

Observe how each part of the cortex is connected with other parts. This diagram is of course simplified to an extreme degree. There are actually thousands of such interconnecting fibers. (After Starr.)

* These "waves" are not records of single nerve impulses, but reveal a synchronization of activity of many cortical neurons in the region of the recording electrode. Thus, the disappearance of a rhythm means not that the neurons have decreased their activity, but only that their synchronization has been interrupted. The alpha rhythm is apparently a resting rhythm. When the occipital region is called on to function in seeing, the various parts perhaps begin functioning independently. Some cells are positive, others negative at the same instant, so that their effects "cancel" one another and the EEG machine records "nothing" or irregular activity.

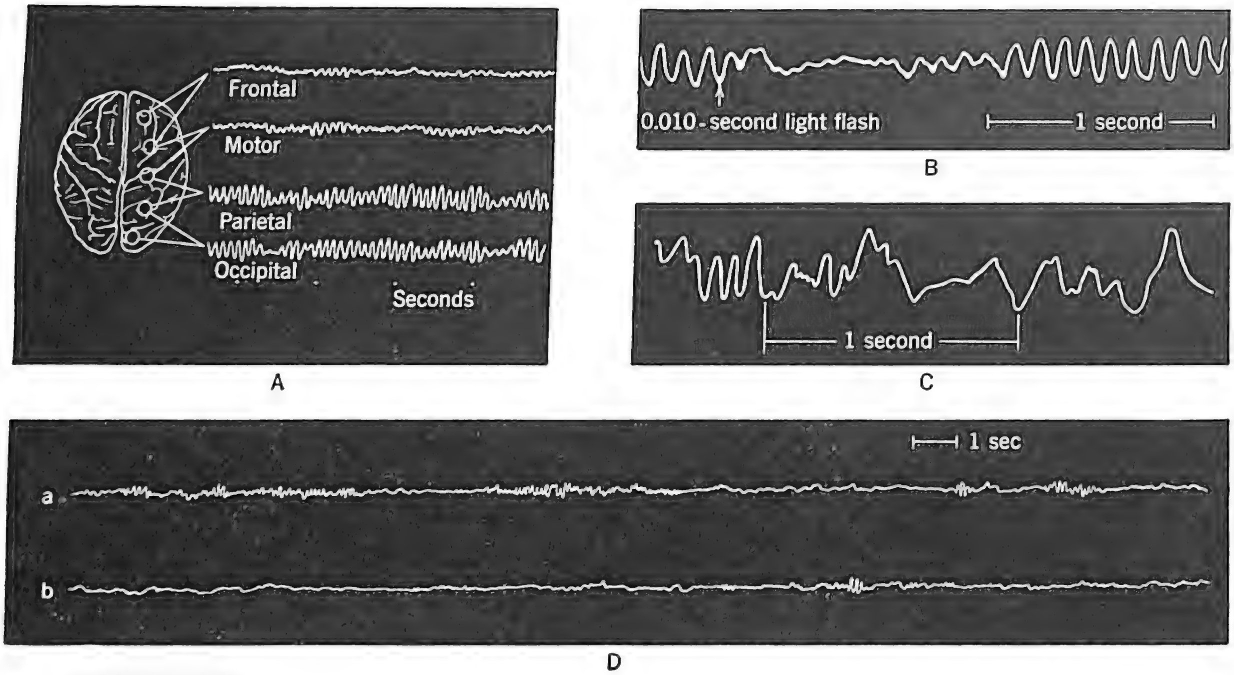


30

Recording Electroencephalograms

The subject, with electrodes attached to his scalp, lies (or sits) in an electrically shielded room — thus shielded so that only the electrical impulses from the brain will be picked up. Electroencephalograms, recorded by the electroencephalograph below, are seen on the moving tape. Here there are six records, each from a different region of the scalp. (Courtesy of the Institute for Living.)

brain tumors. If abnormal rhythms are associated with a specific region and not others, the tumor is usually located in that region. The other practical use of EEG's is in the study of epilepsy. During an epileptic attack the brain rhythms are seriously disturbed and the region in which the disturbance starts may reveal the source of a brain tumor or an adhesion. Even when no attack is being experienced, the epileptic's EEG's lack their normal rhythms, i.e., show dysrhythmia. Dysrhythmical EEG's, even in



31

Cortical Rhythms Recorded by Electroencephalograph

A. *Alpha waves are most clearly evident from the occipital and parietal lobes. Records from the frontal and motor regions are complicated by addition of the smaller beta waves. Observe that the strong alpha rhythm of the parietal and occipital regions has about 10 pulsations per second. The brain map shows the relative positions of the electrodes on the scalp. (Reproduced by permission from Lindsley in* Methods of Psychology *by Andrews, published by John Wiley and Sons, Inc., 1948, p. 448.)* B. *Blocking of the alpha rhythm by visual stimulation. (From Lindsley, p. 449.)* C. *Electroencephalogram from one region of the brain during sleep. (From Kreezer, G., "The Electroencephalogram and its Use in Psychology,"* Am. J. Psychol., *1938, 51, p. 747.)* D. *Mental multiplication compared with "keeping the mind a blank." Line* a *shows an electroencephalogram taken while the subject, with his eyes open and focused in a fixed position, was mentally multiplying two-digit numbers. Line* b *shows a record taken under comparable conditions, but while the subject was trying to "keep his mind a blank." Occasional intrusions of kappa waves in the lower record are attributed to "thoughts" which, the subject said, came even though he was trying to inhibit them. (From Kennedy, J. L., R. M. Gottsdanker, J. C. Armington, and F. E. Gray, "A New Electroencephalogram Associated with Thinking,"* Science, *1948, 108, p. 528.)*

persons who have never had epileptic attacks, are believed to indicate a predisposition toward epilepsy.[9]

A very vivid picture of the modern concept of brain activity, with reverberating circuits and periodically discharging brain cells, giving rise to the EEG's, is conveyed by the following quotation from Sir Charles Sherrington, the world-renowned physiologist.

> Imagine [he says] a scheme of lines and nodal points, gathered together at one end into a great ravelled knot, the brain, and at the other trailing off to a sort of stalk, the spinal cord. Imagine activity in this shown by little points of light. Of these some stationary flash rhythmically, faster or slower. Others are

travelling points streaming in serial trains at various speeds. The rhythmic stationary lights lie at the nodes. The nodes are both goals whither converge, and junctions whence diverge, the lines of travelling lights. . . .

Suppose we choose the hour of deep sleep. Then only in some sparse and out-of-the-way places are nodes flashing and trains of light points running. . . . The great knotted head-piece of the whole sleeping system lies for the most part dark. . . . Occasionally at places in it lighted points flash or move but soon sub-side. . . .

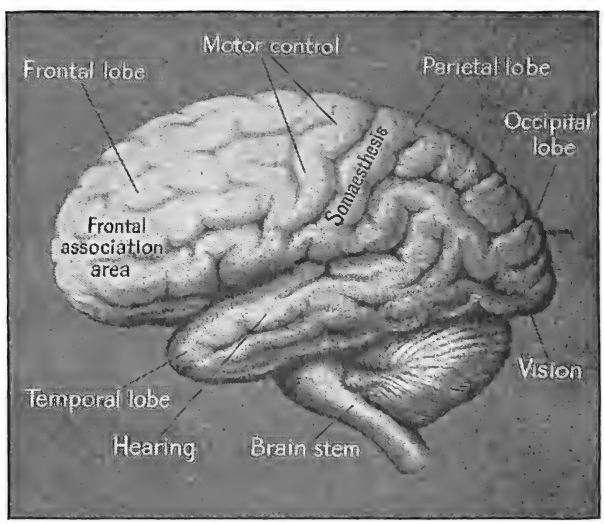
Should we continue to watch the scheme we should observe after a time an impressive change which suddenly accrues. In the great head end which had been mostly darkness spring up myriads of twinkling stationary lights . . . It is as though activity from one of those local places which continued restless in the darkened main-mass suddenly spread far and wide and invaded all. The great topmost sheet of the mass . . . where hardly a light had twinkled or moved, becomes now a sparkling field of rhythmic flashing points with trains of travelling sparks hurrying hither and thither. The brain is waking and with it the mind is returning. It is as if the milky way entered upon some cosmic dance. Swiftly the head mass becomes an enchanted loom where millions of flashing shuttles weave a dissolving pattern, always a meaningful pattern though never an abiding one.[10]

Locating special brain functions

The functions of different regions of the cerebral cortex were discovered by use of the following procedures: (1) by tracing nerve fibers from one part of the nervous system to another. When nerve cells in the eye are destroyed, for example, the attached fibers degenerate, and the degeneration is traced back to centers in the brain stem. Destroying cells of connecting nerve fibers in the brain stem causes degeneration which is traced to the occipital lobe. (2) By destroying regions of the cortex in animals and observing sensory, motor, and associational defects resulting from the operations. (3) By observing the effects of accidental, or necessary operational, injuries to the human cortex. Much information of this sort has been obtained by brain surgeons in the course of their practice, and by neurologists working on the battlefield. (4) By electrical stimulation of the cerebral cortex in animals and in human beings about to undergo brain operations. Since patients are often conscious and able to carry on normal conversation with the surgeon during electrical stimulation, and even during the brain operation itself, much information about the cortical bases of experience may be gathered.

SENSORY FUNCTIONS OF THE CORTEX

Specialized sensory areas are found in the parietal, temporal, and occipital lobes. Their location, as well as that of motor and association areas, is indicated in Figure 32. They are called *sensory projection areas* because impulses originating in receptors are, as it were, projected upon them.



32

The Left Cerebral Hemisphere of the Human Brain

In this drawing are shown the locations of the sensory projection areas of the brain.

Somaesthetic sensitivity

A portion of the parietal cortex located just behind the fissure of Rolando serves as a terminal or projection area for impulses originating in the skin and in kinesthetic receptors. It is called the *somaesthetic* (or body feeling) area. Impulses reaching it from receptors in the skin provide, under normal conditions, the basis of our experiences of temperature and touch. Experiences associated with movement of body parts also normally depend upon impulses sent to this region.

When the somaesthetic area is stimulated electrically in human beings, there are reports of temperature, touch, and movement experiences. These experiences are localized not in the brain, but on or in the body. For example, a man about to have a brain operation was stimulated electrically on the exposed somaesthetic cortex. As the electrode was moved around within this area, the patient reported feelings of warmth and numbness in his limbs, stroking of his finger (although the finger was of course not stimulated), and also feelings of movement in his limbs.[11] Another patient said that he had "electric feelings" in his limbs.[12] In each instance the limb in which the feelings were localized was on the side opposite to that stimulated. The reason for this is that impulses reaching the right cerebral hemisphere from skin and muscles come from the left side of the body. There are no pain, olfactory, gustatory, visual, or auditory experiences associated with stimulation of this area.

A skin sense apparently not represented in the cerebral cortex is pain. No pain has been reported as a result of electrical stimulation in any of the lobes. Moreover, patients have tumors removed from various areas of the cortex and even the cutting involved arouses no pain experience. As already suggested, the patient is frequently conscious, and carries on a conversation with the surgeon while he is operating. This suggests that pain sensitivity is dependent upon connections in the thalamus and not in the cortex. It is interesting to note, furthermore, that sensitivity to touch and temperature continues to exist in human beings after removal of parietal tissues. Thus, while the cortex normally is involved in skin sensitivity, it is not essential. Thalamic connections are sufficient.

In the cases of vision and hearing, the cortical projection areas are not so easily dispensable. The thalamus mediates elementary visual and auditory sensitivity in animals like the rat. But human beings are completely blind or deaf if the respective cortical areas are destroyed. Only unconscious reflex response to visual and auditory stimulation occurs in such cases.

Visual sensitivity

Impulses coming from visual receptors end in the occipital lobe. As shown in Figure 32, their terminus is at the tip of this lobe. The visual area in the right cerebral hemisphere receives impulses from the right half of each eye and in the left cerebral hemisphere from the left half of each eye. (See Figure 210.) If the visual cortex of the right hemisphere is destroyed, the right half of both eyes becomes blind. Total blindness resulting from cortical injury could occur only if the visual areas were destroyed in both cerebral hemispheres.

The epileptic is often warned of a coming fit by flashes of light, whirling colors, and similar visual experiences. In such cases there is frequently irritation of tissues in the visual cortex caused by tumors or other abnormal conditions. This irritation arouses visual experiences such as might occur if the eyes from which the fibers come were themselves stimulated. A patient whose exposed visual cortex was stimulated electrically said she saw "something pink and blue." Stimulated again, but at another

point, she saw "a star." Another patient saw "whirling colors" while the surgeon was cutting into his visual cortex.[13]

Auditory sensitivity

Nerve impulses initiated in the ears eventually find their way to the auditory area of the temporal lobe. Destruction of the auditory cortex in one hemisphere causes only minor defects of hearing.[14] The reason for this is that each ear has representation in both hemispheres. If both auditory areas are destroyed in man, however, he is completely deaf.

Auditory experiences are often reported just preceding epileptic fits involving the temporal lobes. Electrical stimulation or cutting of the auditory area results in humming, buzzing, and even musical sounds.[15]

MOTOR FUNCTIONS OF THE CORTEX

The motor cortex of human beings is a relatively narrow strip of tissue which runs along the frontal portion of the fissure of Rolando, as illustrated in Figure 32. Within this area, as previously mentioned, there are large cells shaped somewhat like pyramids, hence the name *pyramidal* is attached to them and their fibers. Destruction of pyramidal cells leads to a degeneration of their fibers which are then traced to levels of the brain stem or spinal cord on which synaptic connections with efferent neurons occur. Some of the fibers originating in these cells cross to the opposite side of the body in the medulla (see Figure 28). Those not crossing at this level do so just before they connect with efferent neurons. For this reason, the motor area of one cerebral hemisphere controls the opposite side of the body. Destruction of the motor area on one side is followed by loss of voluntary movement on the other side of the body. Although voluntary movement is lost in the corresponding limb when a portion of the motor area is destroyed, the individual is able to move the limb reflexly in response to strong stimuli. This is because reflex arcs are still functioning at lower levels.

It was once thought that paralysis produced by cortical injuries was permanent. Experiments with rats and monkeys, however, demonstrated that limbs paralyzed by destruction of cells in the motor cortex sometimes recover their functions. This suggested that paralyzed human beings, if given suitable training, might also recover the use of paralyzed muscles. The suggestion proved worth while, for massage and attempts to move paralyzed members in various ways have frequently yielded successful results.

There was a soldier aged thirty years who, as the result of a lesion in the motor cortex, had been paralyzed in one arm for six years. Massage and passive exercise of the arm (i.e., exercise produced by another and by the individual himself with non-paralyzed muscles which enabled him to move the arm as a whole) began to show results after four months. By repeated attempts to move the paralyzed muscles themselves, the soldier eventually regained ability to bend his elbow, raise his arm, flex his wrist, and so on. He even played ball, but with relatively poor skill.

Then there is the somewhat similar case of a woman of fifty-eight who had been paralyzed in one arm for years. The psychologist-physician who worked with her, as well as with the soldier just mentioned, reports that after some weeks of re-education she was able to

> perform many complex movements of the arm including those required in sewing. About eight weeks after I began to work with her I found that she had acquired the ability to oppose the forefinger and thumb. I then took a wide muslin bandage on which I turned over a hem. I took two stitches to indicate how and what I wanted her to do. Then handing her the threaded needle and cloth she found that she was able to do this work. At first her move-

ments were slow. She made only twenty-one stitches in five minutes, and the individual stitches were irregularly placed and irregularly directed. At the end of five weeks, she averaged thirty-three and five-tenths stitches in five minutes, but they were fine and regularly placed.[16]

Both of these patients had injuries in the motor cortex. Pyramidal cells were irreparably destroyed. Yet the parts normally controlled by these cells recovered their functions. The reason offered is that neighboring cells, as a result of the training procedures, were "induced" to take over the lost functions. This substitution of neighboring cells for those lost is referred to as *vicarious functioning*. Such functioning rarely, if ever, occurs in cases of injury to sensory projection areas, but it is often reported in cases where motor or association tissues are involved.

Electrical stimulation of the motor cortex has led to the discovery of regions which control various parts of the body. When the upper region is stimulated electrically, for example, the lower limbs on the opposite side of the body, or parts of them, are forced to move. When the lower region is stimulated, the face may twitch, the mouth be opened or closed, and so on. The points from which these responses are aroused usually change somewhat from time to time. Sometimes stimulation on a particular point arouses a response, and at other times it does not. The reason for this is probably that what occurs in a particular region at any moment is influenced by what has been and is occurring in neighboring cells with which it is connected. Two authorities on epilepsy, who have themselves stimulated many human brains, say:

> The cerebral cortex is not a key-board which can be struck with the expectation that an invariable response will be the result. It is a structure containing many different neural circuits which subserve many functions. Stimulation at a point may activate one of these circuits and not others, so that a single response occurs and not a mixture of responses, but the other elements are there just the same. Response from an individual point in the cortex depends upon antecedent influences and coincidental influences of many types. . . . Functional localization exists in the cortex, not in "centers" or "points," but in arcs and patterns that extend into various regions of the brain. For example . . . one point may invariably yield movement of the thumb. We are entitled to conclude from that fact, not that thumb movement is represented at that point, but only that a part of neural connections involved in causing the thumb to move is to be found there.[17]

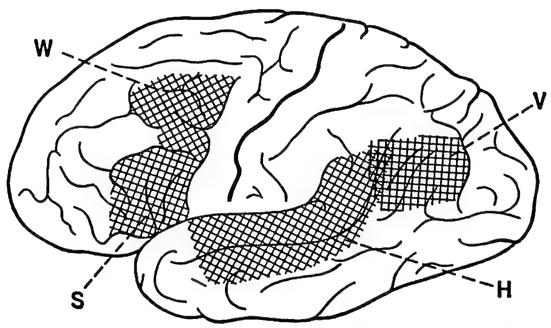
ASSOCIATIVE FUNCTIONS

The cerebral cortex is a device not only for receiving sensory and initiating motor impulses, but also, through its association neurons, for connecting, relating, and integrating functions. These integrative functions of the cortex plus its susceptibility to modification during an organism's lifetime, provide the foundations of such psychological processes as learning, recalling past experiences, and thinking. So far as relatively simple learning processes are concerned, the associative functions of a rat's brain are not specialized. The more brain tissue one removes, the greater the number of errors made in learning a maze. But it does not matter from what area we remove a particular amount of tissue.[18] This principle of mass action, and its explanation, are considered more fully in the chapter on foundations of learning. In the present instance we are interested primarily in the human cortex and in typically human psychological processes. Here we find specialization of particular regions for complex associative functions like understanding spoken words, writing, reading, recall, and reasoning. It is convenient to refer to these specialized association areas as *sensory, motor,* and *frontal.*

Speech functions

When modified tissues of sensory and motor association areas (see Figure 33) are destroyed, the situations which modified them lose their significance. Consider, for example, the condition known as *aphasia,* or loss of speech functions. The individual with aphasia learned, as a child, to read, write, speak, and to understand speech sounds made by others. Destruction of cortical association tissues, however, "wipes out" what he has learned. This shows that "traces" of some kind are left to represent past experience. Rearousal of these traces allows one to reproduce, as it were, the circumstances which made them. With the traces gone, corresponding gaps in related abilities are present.

Destruction of the auditory speech area (H) is followed by *auditory aphasia,* or *inability to understand spoken words.* This is not a sensory defect as such, for the person may hear perfectly well. Nor is it basically a motor defect, for he may speak and write. He has merely lost the meaning of speech sounds. In this regard, the aphasic individual is as handicapped as an infant who has not yet acquired an understanding of speech.



33

The Left Side of the Human Brain, Showing Association Areas Especially Involved in Language

According to most authorities, the left side of the brain is normally specialized for linguistic functions. Damage to V *usually produces "word blindness" (or alexia), a disorder in which the subject sees written material but does not understand its meaning. Damage to* H *is associated with "word deafness." The subject hears the spoken sounds but does not know what they mean. Articulate speech is disturbed by injuries to region* S, *and writing by injuries to area* W. *All of these language disorders are grouped under the general term* aphasia, *which is, literally,* loss of speech. *(After Donaldson.)*

Destruction of the visual association area (V) is followed by *alexia,* which is *loss of ability to understand written language.* The individual sees perfectly well, for he may trace the letters. He has merely lost his understanding of them.

Likewise, ability to speak and to write in a meaningful fashion is lost after destruction of association areas (S and W) near the motor cortex. One thus afflicted may be able to move his vocal mechanisms and to make marks with a pencil, but the sounds and marks have no meaning. They are as meaningless to us as the untutored vocalizations and scribblings of a child. What was learned has been lost, because the neural traces produced while learning was taking place have been destroyed.

Brain injuries are not usually confined to a particular area; hence, aphasia usually involves a mixture of the above-mentioned conditions. Moreover, aphasia in the right-handed is usually associated with injuries in the left cerebral hemisphere and in the left-handed with injuries in the right cerebral hemisphere. This underlies the view that the left hemisphere, as far as both handedness and speech functions are concerned, is normally dominant.[19]

That individuals with aphasia may recover their lost functions is demonstrated in reeducation experiments similar to those already discussed in connection with recovery of motor functions. A psychologist who has worked with many such cases comments as follows concerning the recovery process:

The individual begins with nothing and slowly, as a child, he reacquires what he has

> lost. It is mainly by a process of trial and error, as in the case of animal learning. The patient is asked to name an object, or to read a printed or written word. This he cannot do, let us say. The word is then given him verbally and he tries to repeat it. He may or may not succeed, and if asked again within five minutes he may give an entirely different collection of sounds. By repetition he may eventually be able to say the word whenever it is demanded, but the learning process is slow, and there are many errors before definiteness and certainty of response are attained.[20]

Similar instances could be cited of individuals who, as a result of training, recovered ability to read, to name colors, to write, and to play pieces of music.

Which of the remaining brain tissues substitute for those lost is not known. Some believe that the opposite cerebral hemisphere is modified in the relearning process; others that association tissues neighboring upon those destroyed take over their functions. At least we can conclude that new modifications are produced somewhere within the cortex, and also that new connections of nerve fibers are established. The psychologist whom we have just quoted gives the following analogy, but with the caution that it should not be taken too literally:

> Let us suppose that a storm in the mountain has broken the telephone cables connecting this city [Los Angeles] with northern points, or that the main station through which northern messages go has been destroyed by fire. For the time being communication is suspended. The social function is lost. Direct messages are impossible. But relays and indirect communication may be possible. The telephone lines to Salt Lake City, those from Salt Lake City to Sacramento and to San Francisco may remain sufficiently intact to function. If these accessory, but circuitous lines are working, it is still possible, though with some difficulty, to get communications through to the north. The functional loss is compensated for by less direct activities.[21]

Frontal association areas

The frontal association areas are important for certain complex associative processes. This has been shown in experiments with animals ranging from rats to apes; and in observations on human beings who have injuries in both frontal lobes. The processes particularly affected are recall of recent experiences, reasoning, and motivation. Marked personality changes are at times involved.

Monkeys and apes, for example, normally remember under which of two identical cups they have seen food placed. The typical experiment is to confront an animal with two upturned cups, one to his right and one to his left; to put food under either cup while the animal is looking; to place a screen between the animal and the cups; and to disorient him so that he cannot continue to stare at, or keep his body turned toward, the correct cup. After a predetermined interval, the experimenter raises the screen and releases the animal. To be scored correct, the animal must go directly to the cup under which food was placed. The right and left position of the correct cup varies in a random order from trial to trial, both cups are smeared with food so that no odor cue will be present to guide the animal, and the experimenter is hidden from view so that no attitudes or movements of his will be seen. In short, the animal can respond with consistent accuracy throughout a number of tests only if he remembers under which cup the food was placed. Monkeys and chimpanzees tested in the above fashion normally exhibit consistent accuracy after periods ranging from several minutes to several hours.

When association areas outside the frontal lobes are destroyed, there is no disturbance of ability to recall the correct cup. Moreover, destruction of only one frontal area has no effect. It does not matter whether the

area destroyed is in the right or the left hemisphere; hence there is, so far as memory is concerned, no dominance of one side. When both frontal association areas are completely destroyed, however, the animal fails to perform correctly, even after as short a period as two seconds. Partial destruction of both sides does not abolish ability to respond correctly, but it does reduce the time which may elapse between seeing the food placed and ability to locate it correctly.[22] Failure to perform this test correctly after the frontal association areas have been removed may be due to loss of memory for recent events. But it may also result from an increased distractibility — a poorer ability to pay attention — or from an instability of the neural traces which underlie recall. Stimulation by light, for example, may "wipe out" traces in the brain of an operated monkey yet not disturb those in the brain of a normal animal.[23]

An interesting further outcome of such experiments is the personality change which occurs. The normal animal shows much excitement while the cups are baited, and especially after he has made an error and lost the opportunity to get food on that trial. But the operated animal remains quite passive and undisturbed. As some investigators have put it, "It was as if the animal had joined the happiness cult of Elder Michaux, and had placed its burdens on the Lord."[24]

Removal in human beings of large amounts of association tissue in one frontal lobe has practically no influence upon scores made in intelligence tests, tests of memory, and reasoning.[25] When large areas of destruction occur in both frontal lobes, on the other hand, there is often an apparent weakness of memory for recent events which is comparable to the findings for monkeys and chimpanzees. There is, however, no loss of childhood memories.

Sometimes, following such operations, the defect appears to be emotional and motivational more than intellectual, as the following quotations suggest:

> In one of the most carefully controlled studies of frontal-lobe function, an intelligent patient was studied intensively for many months. Because of a tumor, a large part of both frontal lobes had to be removed (the right specimen weighed 108 grams, the left specimen 121 grams, thus making a total cerebral loss of 229 grams). This operation was performed by Dandy. The subject was a stockbroker who owned a seat on the New York Stock Exchange. As a result of the operation just described, the patient's personality underwent certain changes, but they were less intellectual than emotional alterations. Whereas before the operation the patient had been rather taciturn, he now became boastful. After the operation, he showed less regard for the feelings and welfare of his family than before. The simple elements of old and new associative material, however, could still be completely understood by the subject. He seemed less able, however, to utilize diverse material in forming complex syntheses than had been characteristic of him before. Yet he was still able to solve mathematical problems involving the use of algebra, and it was still possible for him to memorize a poem when he was asked to do so.
>
> This case is interesting in relation to the famous "crowbar case" reported many years ago in which a laborer lost a large part of the frontal part of the brain in a blasting accident and showed very little intellectual change following his recovery from the accident though his temper became more violent and his general emotional control less effective than it had been.[26] . . . The present evidence seems to indicate that a loss of the frontal lobes rather subtly affects the entire mental life of the human individual. The emotional and motivational, as well as the intellectual, behavior is changed characteristically, though sometimes only very subtly, in unfortunate individuals who have lost large parts of their frontal lobes. This observed fact suggests that the frontal lobes are involved in the intellectual functions characterized by "drive." The frontal lobes also seem to involve the capacity of an individual to synthesize past learned

34

Alteration in Facial Expression Following Prefrontal Lobotomy

The change in personality suggested here is typical of that which usually follows prefrontal lobotomy. The patient is shown before the operation in the picture at the left, and seventeen months after lobotomy at the right. (From Freeman, W., and J. W. Watts, Psychosurgery, *2nd Edition. Springfield: Thomas, 1950, pp. 413–414.)*

acts or associations into very complex conceptual wholes.[27]

In recent years there has been widespread use of an operation known technically as *prefrontal lobotomy,* in which connections between parts of the frontal association areas and the thalamus are cut.[28] Both frontal lobes are involved. This operation, sometimes referred to as "psychosurgery," is a last resort in certain behavior disorders, particularly those involving extreme self-consciousness and depression. Many people are improved emotionally after the operation. Such improvement is suggested by the photographs in Figure 34. Without seriously reducing intelligence, as measured by standard tests, the operation usually leaves a person less anxious, less self-conscious and more serene.[29]

Thus the frontal association areas are seen to be extremely important, not only in making possible our higher psychological abilities but also in controlling aspects of emotion and personality.

SUMMARY

All psychological processes are responses of organisms to stimuli; hence, those characteristics of animals which enable them to respond to stimuli are of central importance for psychology. The response systems of organisms grow out of the properties of protoplasm, as found in ameba. Although this simple organism has no receptors, neural mechanisms, and effectors, it is sensitive to certain changes in its environment. The effects of these changes are conducted from one part of the protoplasm to another. Each bit of protoplasm is capable of movement. In higher organisms than animals like ameba, we find sensitivity mediated by receptors, conduction by neural mechanisms, and motility by effectors. As receptors developed complexity, organisms became sensitive to more and more environmental detail. As effectors became more complex, dexterity of movement developed. This culminated in the human hand which is the basis of our control of fire and invention of implements and weapons. As nervous mechanisms evolved, in close relation to receptors and effectors, organisms could more readily adjust to their environment through learning the significance of stimuli. With increasing complexity of neural organization there developed such psychological functions as memory for past events, reasoning, and speech.

Development of neural mechanisms began with the appearance of fibers connecting receptors in the skin with muscles situated some distance below. After this came a nerve net which spread impulses to all parts of the organism. Neural connections then became more specific, finally producing complex circuits in which the sensory, motor, and association neurons made contact through synapses.

The sensory (afferent) and motor (efferent) neurons have fibers which, arranged like wires in a cable, make up our peripheral nerves. Many of the association neurons, within the central nervous system, form ascending and descending bundles which convey impulses to and from upper levels of the nervous system, including the brain. The cerebral cortex is a vast complicated network of association neurons connected synaptically.

Neural evolution involved increasing centralization of function. Centralization of a relatively simple kind is found in the nerve ring of the starfish. The highest degree of centralization, however, occurs in the brain. We have considered various developments in the brains of animals ranging from fish to man. The most significant of these were an increase in the size of the cerebrum relative to body weight and to the weight of the spinal cord, invagination of the surface to provide more space for association neurons of the cortex, and an increase in the relative amount of the cortex given over to functions of association.

While all psychological processes depend upon the organization of our neural mechanisms, they are also dependent upon the characteristics of the nerve impulse. This is an electrochemical disturbance, which travels along nerve fibers, much as explosions traverse a fuse. The energy is in the nerve fiber, but it is discharged as the preceding discharge sets it off. These waves of disturbance passing along a nerve fiber can be recorded. Their electrical potential is the same for nerve fibers serving different functions (sensory or motor), hence the nature of experience cannot be accounted for on the theory that different kinds of nerve impulse are aroused by each kind of receptor. What determines the kind of experience is the *place* in the cortex to which the impulses go. If a fiber discharges at all, its potential is the same, so that even different intensities of experience, and of response, cannot be attributed to different strengths of nerve

impulse. The only way nerve impulses vary with intensity of stimulation is in their frequency — the discharge being more frequent the more intense the stimulus. Actually a stronger stimulus activates each fiber more often than a weaker one and it also activates more fibers.

Our nervous system, like that of all other vertebrates, has two major divisions, the central and the peripheral. The central nervous system comprises the brain and spinal cord. Nerves emerging from the brain and spinal cord, as well as their outer connections, make up the peripheral nervous system. Motor nerves which connect with the visceral and other internal organs are referred to as the autonomic nervous system. Of this system there are two major divisions, the sympathetic and parasympathetic. These systems work in opposition, so that an organ whose functions are accelerated by one are inhibited by the other. Discharges from the sympathetic nervous system are especially involved in emotion. Internal organs also have afferent neurons, carrying impulses to the central nervous system. Thus we have some awareness of internal activities.

Each impulse which enters the spinal cord may travel, over association neurons, to an efferent neuron, and out to a muscle or gland. But impulses are not confined to such reflex arcs. They also travel up the cord, making connections in the brain stem and cerebrum. Impulses from different kinds of receptors (temperature, contact, proprioceptive) ascend the spinal cord in different tracts. Motor impulses descend the spinal cord in still other tracts, ultimately reaching the efferent nerves and muscles or glands. Within the spinal cord and at upper levels, there are reverberating or self-exciting circuits, which keep impulses going after external stimulation has ceased. These circuits are especially complex among the billions of neurons which make up the cerebral cortex. Such circuits perhaps account for the electrical brain rhythms recorded with the electroencephalograph. The most prominent rhythm is the alpha, with approximately ten oscillations per second.

The brain has two cerebral hemispheres, connected through the corpus callosum and together known as the cerebrum. Its outer layer is the cerebral cortex. The brain stem begins in the region of the corpus callosum and ends at the spinal cord. Back of it is the cerebellum, a structure of great importance for motor co-ordination. Of the structures of the brain stem, the most significant psychologically are the hypothalamus and thalamus. The hypothalamus is especially involved in sleep and emotion. The thalamus serves as a switchboard mechanism, relaying impulses to appropriate sensory projection areas of the cerebral cortex. It also mediates a certain degree of sensitivity as well as primitive learning functions.

The cerebral cortex has specialized projection areas for the somaesthetic, auditory, and visual senses and also specialized regions which play a large part in the control of voluntary motor activities. Vicarious functioning of other neurons sometimes follows the destruction of motor tissues.

Association functions of the human cortex, although somewhat specialized, are less specialized than sensory and motor functions. The modifiability of cortical association neurons during an individual's lifetime is especially important. Connecting, relating, and integrating activities of the cortex are necessary for language functions, recalling, and thinking. Brain injuries may cause paralysis, aphasia, and disturbances of memory and reasoning, but they also frequently produce personality changes. Sometimes, as in prefrontal lobotomy, operations are performed on mental patients to bring about certain personality changes — especially to reduce self-consciousness and to eliminate an unhappy disposition.

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4 THE GROWTH OF BEHAVIOR

Life Begins • Growth of the Nervous System • Growth of Receptors and Effectors • Behavior of the Unborn: The first response; growth of the response repertoire • Birth and After: Sensitivity at birth; behavior of the newborn • Locomotion: The sequence of locomotor development; the mechanics of locomotion • Prehension • Language: Gestures; speech; writing • Summary

MAN'S PSYCHOLOGICAL PROCESSES, we have seen, are the final outcome of a long biological history which began with the sensitivity and behavior of animals like the ameba. Our attention now turns to the psychological significance of the individual's biological history and especially to the correlation between the developing organism and its behavior.

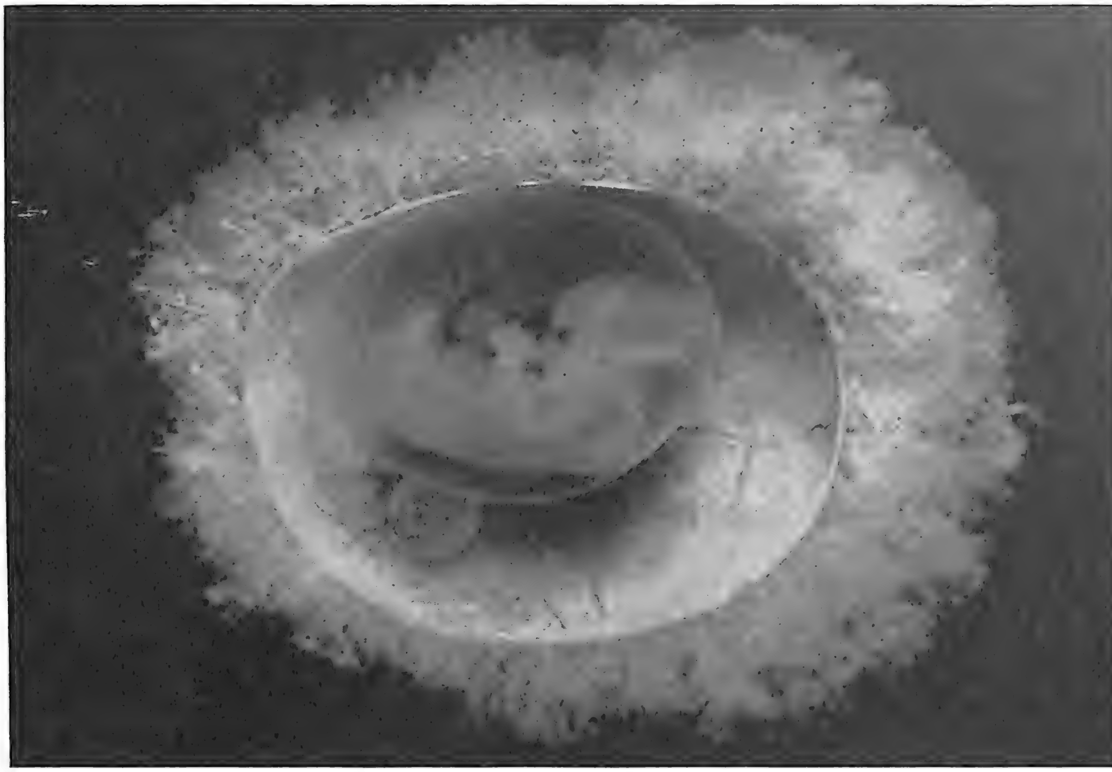
To cover the whole range of development from conception to maturity would require a volume in itself. But the early stages are most significant for us. During these stages all of the basic psychological processes make their appearance. Later development merely involves the use and elaboration of these processes.

In considering psychological development, it is well to start from the beginning of life, from conception. The reason for this is that, at the moment of conception, forces are set in motion and conditions begin to operate which are influential in shaping the course of all future development. No psychological processes are evident until long after conception, but factors present from the time of conception determine, to a very large extent, what these processes will be.

LIFE BEGINS

Each of us begins life as a single fertilized cell smaller than the head of a pin. At first an ovum (egg) develops, and becomes susceptible to fertilization. Soon after fertilization takes place the ovum divides to form two cells. These divide to form a total of four, these again to form a total of eight, and so on, until a small ball of tightly packed cells is formed. Shortly after the ball of cells appears, liquid enters and forces the cells apart. This forms a cavity in the cellular mass. The human body develops from one group of these cells. The remaining cells form two protective envelopes, including a liquid-filled sac (Figure 35) in which the fetus develops until the sac's rupture precipitates its birth.

For two weeks after conception the child, since it is still in the germinal period, is known technically as an *ovum*. Soon a portion of the outer sac becomes attached to the uterus. This is the portion from which the child is later suspended by the umbilical cord. (Figure 55, p. 97.) From two weeks until about two months after conception, the organism is technically an *embryo*. During this period it begins to get its nourishment from, and excrete waste products through, its mother's circulatory system. This exchange occurs at the point of attachment, by seeping of materials through neighboring membranes rather than by actual joining of



35

A Human Embryo of Six Weeks

The woman from whom this embryo was removed became ill and was forced to have her pregnancy terminated. The larger sac is what would later have become the placenta, bringing nourishment from and eliminating waste products through the mother's circulatory system. The inner sac is the amnion. It is filled with a protective liquid, the amniotic fluid. The yolk sac, which nourishes the embryo during its early growth, is shown below the amnion, just under the embryo's hip. (Photo by Chester F. Reather, Dept. of Embryology, Carnegie Institute of Washington. © International.)

the embryo's with its mother's circulatory system.

Meanwhile, the embryo's cells are multiplying and it is becoming larger. In addition to multiplying, however, the cells are differentiating — that is to say, changing in shape and internal structure. Some are becoming nerve cells, others bone cells, still others muscle cells, and so on. This process continues until the embryo gradually assumes human shape. By the end of two months from conception, it has a primitive nervous system, the rough patterns of human eyes and ears, the forerunners of human bones and muscles, and elementary hands and feet. It is, however, without sensitivity and without movement, except that its heart is beating and its muscles, such as they are, could be made to twitch if pinched or subjected to other intense stimulation applied directly. From this stage (two months) until birth, the organism is known as a *fetus*.

Shortly after the fetal period begins, human response systems develop to the point where stimulation of the face or head, with even a thin hair, would be sufficient to

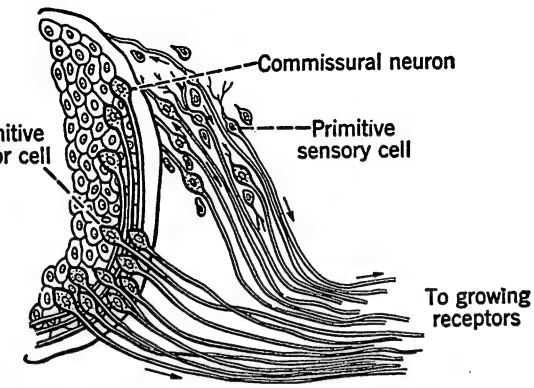
initiate activity. This would arouse activity not only in parts stimulated, but in the trunk and limbs. The fetus's skin receptors are now sensitive to stimulation, and its effectors are sufficiently developed to respond to nerve impulses. If it could be available for observation, the fetus would now be a fitting subject for psychological investigation.

GROWTH OF THE NERVOUS SYSTEM

The nervous system is the first response mechanism to emerge from the multiplying and differentiating cells of the organism. At first a crude pattern is laid down, then the spinal cord, brain stem, and cerebrum gradually emerge. While this process is going on, the receptors and effectors also appear. Upon first appearance, these are but crude patterns of what they will become. Finally, the receptors, neural structures, and effectors are linked together, as described in the preceding chapter.

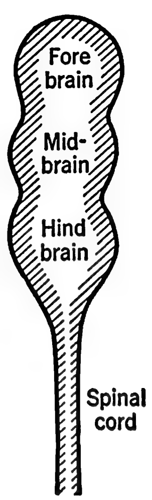
At an early stage in its growth, long before behavior is possible, the nervous system is a hollow tube with three bulb-like structures at one end, as illustrated in Figure 36. These bulbs develop into the various brain structures and the stem becomes the spinal cord.

Our peripheral nervous system is an outgrowth from the neural tube. Its general course of development is suggested by Figure 37. This shows how the reflex-arc system, which functions in our earliest responses to external stimulation, is laid down. Fibers grow out from the spinal cord and eventually into developing receptors and effectors. Observe that the primitive nerve cells, from which axons grow toward effectors, are situated within the spinal cord. Fibers which grow out toward the receptors, on the other hand, originate in primitive nerve cells outside of the cord. Fibers also grow from these cells into the cord. Eventually they make synaptic contact with motor fibers, either directly or through association neurons, which develop from cells within the developing gray matter. Cells within the spinal cord also send fibers to the brain.



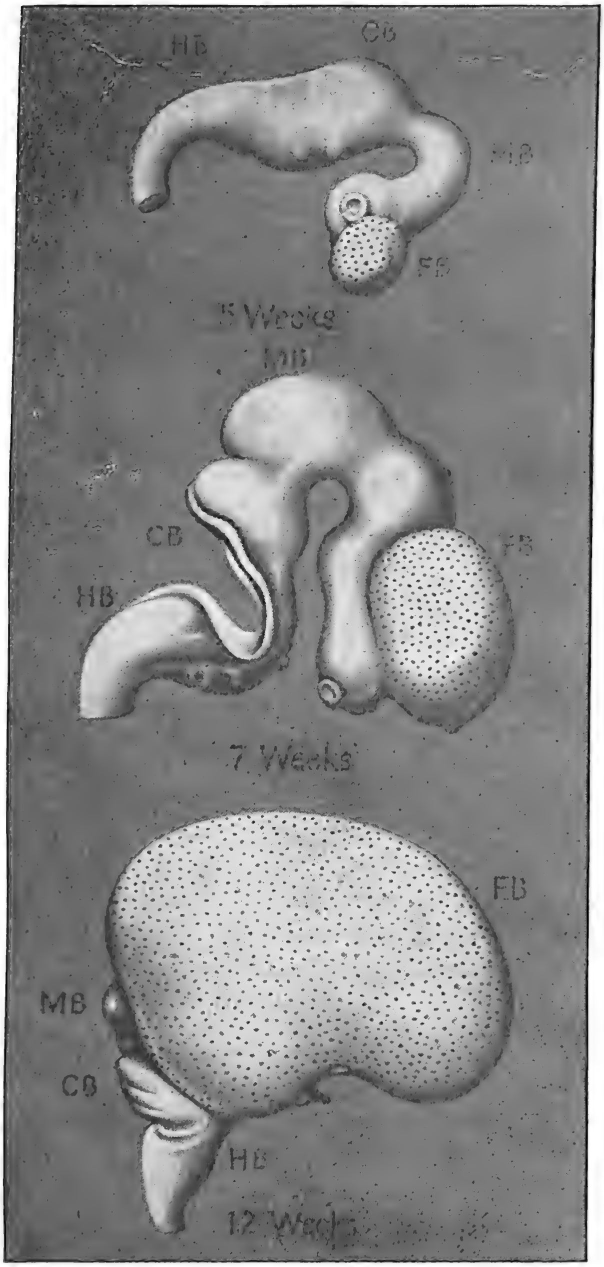
37 **Diagram to Illustrate Early Growth of the Reflex-Arc System**

Arrows indicate the direction followed by growing nerve fibers. Fibers connect with both sides of the cord. Only the right side is shown. (Based upon a drawing in Arey, L. B., Developmental Anatomy, *4th edition, p. 413.)*



36 **The Neural Tube from Which the Brain and Spinal Cord Develop**

In an upright organism like man, the "forebrain" is of course the uppermost rather than the foremost part, but a common terminology is used for all vertebrate brains.



38

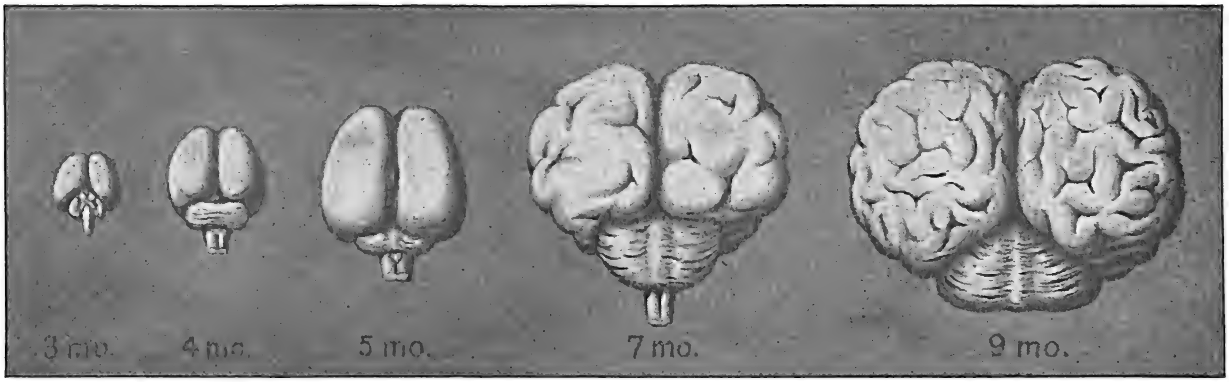
Growth of the Brain During the Early Weeks of Prenatal Life

FB, *forebrain;* MB, *midbrain;* HB, *hindbrain;* CB, *cerebellum. The stippled region is the developing cerebrum. (After an illustration in* Scientific American, *Oct. 1948, 179, p. 28.)*

These form the groups of ascending tracts which carry the effects of stimulation to our brain. Other cells within the developing brain give rise to the descending tracts, those tracts which, as we have seen, make voluntary movement possible. All of these developments occur while the receptors and effectors are themselves still growing. Except for its heartbeat and the fact that certain muscles will contract if strong stimulation is applied to them, the organism is motionless during this period.

The uppermost bulb shown in Figure 36 is the forebrain. It gives rise to the cerebral hemispheres, thalamus, and hypothalamus. From the other bulbs (midbrain and hindbrain) grow the remaining structures of the brain stem. The growth of a human brain between the ages of five and twelve weeks after insemination is illustrated in Figure 38. Observe that the cerebrum, at first a relatively inconspicuous part of the brain, soon becomes the dominant structure. As shown in Figure 39, where it is viewed from above, the cerebrum is still smooth at four months. Invaginations are, however, quite evident by the seventh month. Growth of the cerebellum, necessary for motor co-ordination, is also shown. At birth, the brain is only one-fourth of its adult weight. Most of the growth which occurs after birth is in the cerebrum. This results from a continuation of growth processes started before birth (maturation) as well as from the effects of stimulation and activity (exercise). Maturation and exercise as factors in child development are given special consideration in the following chapter.

More marked, even, than the gross changes in complexity already mentioned are developments occurring within the microscopic structure of the brain. Nerve cells multiply rapidly. Many migrate to the surface, where they form the cerebral cortex. The fibers of each cell grow out to make synaptic connections with fibers from other cells, thus forming the cortical association system. Some parts of the child's cerebral cortex become specialized to serve as terminals for reception of visual impulses,



39

The Growth of the Brain During Fetal Life

The brain is viewed from above and behind. Observe the increase in size and the presence of invaginations by the seventh fetal month. (After Retzius and Broman, from Gilbert's Biography of the Unborn. *Baltimore: Williams and Wilkins, 1939, p. 84.)*

others for auditory impulses, and so on. Fibers grow into these from cells in special subcortical sensory centers. From cells in the motor areas of the cortex, fibers grow downward to the spinal cord. Here, as we have already suggested, they eventually make functional connection with motor neurons and provide channels for later voluntary control of movement. Some cells send fibers to the opposite side of the brain, forming the corpus callosum, which coordinates the functions of the two hemispheres.

Probably almost all of the child's more than nine billion brain cells are present when it is born, for postnatal growth of the nervous system is due primarily to increases in the size and length of neurons.

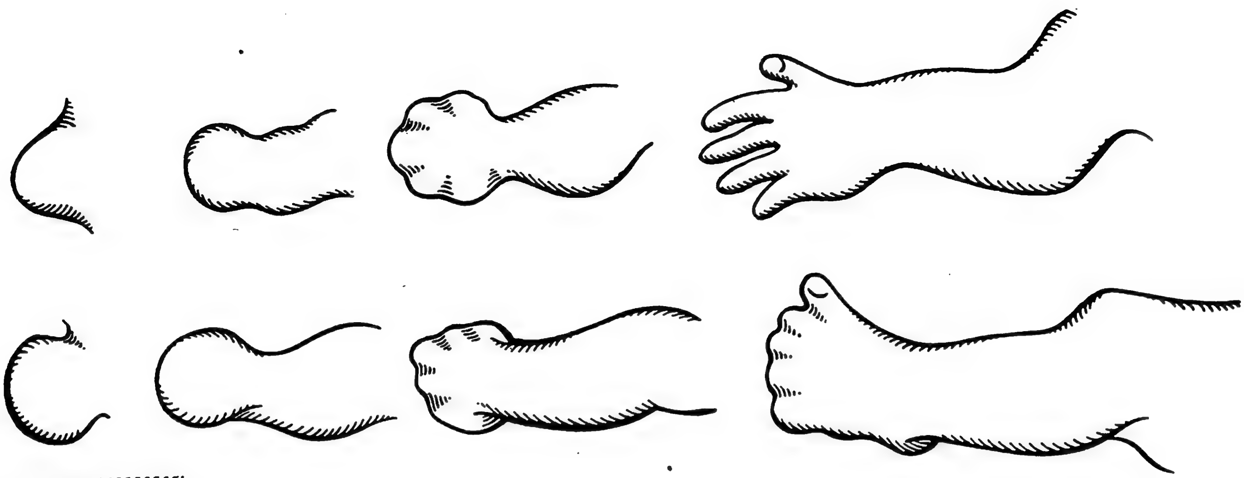
GROWTH OF RECEPTORS AND EFFECTORS

Receptors and effectors are, of course, growing at the same time that fibers from the central nervous system approach them. However, the most important parts of some receptors are outgrowths of the nervous system itself. This is especially true of certain skin receptors, and of receptors in the nose, eye, and ear. The latter three are partly outgrowths of the brain.

Receptors in the nose are direct outgrowths of the olfactory bulbs, which lie directly above the nose. The eye begins as an outgrowth of the brain. A stalk grows from the brain stem toward the outer layer of the head. As it nears the outer layer, part of this layer thickens and turns inward (invaginates), eventually forming a lens. The optic nerve and retina are differentiations of the primitive optic stalk which grows out from the brain stem.

The ear begins as an invagination of the skin. A small sac develops to form the structures of the inner ear. Fibers grow to these structures from the brain stem. Fibers from the auditory nerve, accessory structures of the inner ear, and the middle and outer ear develop from neighboring tissues.[1]

All receptors are well along in their development before the third month of prenatal life. Some of them begin to function as early as the third month, while others have to wait until appropriate stimuli are presented at the time of birth. Those which begin to function early are the receptors for touch



40

Development of the Human Limbs Between the Fifth and Eighth Weeks

Observe that the development of the hand at the eighth week is in advance of that evidenced by the foot. (After Arey, L. B., Developmental Anatomy. *New York: Saunders, 1940, p. 159.)*

sensitivity, for kinesthesis, and possibly for static or equilibratory sensitivity.

Soon after the neural tube develops, a shell of cartilage envelops it. This cartilage differentiates to form the vertebral column and skull. Other parts of the skeleton are also first laid down crudely in the form of cartilage. As the child grows, these differentiate and ossify to form the separate bones of its skeleton. The tendons and striped muscles develop at the same time and become attached to the growing skeleton.

The limbs first look like buds on the sides of the body (Figure 40). As they grow outward, crude patterns of hands and feet appear. At the same time, motor axons are growing toward the muscles. Early in the third month these make connection with the limbs so that neurally mediated movement is possible.

The other effectors (the glands) are of two general kinds: (1) *ductless* or *endocrine,* which pour their secretions into the blood stream directly, and (2) *duct,* like the tear and salivary glands, which secrete elsewhere than into the blood stream. The endocrine glands (thymus, adrenal, and so on) develop earlier than the others. Their secretions play an important part in the development of the fetus. The duct glands, on the other hand, play no known role in development or in behavior until the child is born.

BEHAVIOR OF THE UNBORN

Mothers are usually not aware of fetal movements until between the fourth and fifth months after conception. That movement actually can, and probably does, occur before that time is shown by several types of observation, including application of a stethoscope to the mother's abdominal wall. The most enlightening observations, however, have been made on fetuses which, because the mother's health required it, were delivered prematurely by means of a Caesarean operation. Unless they are six to seven months old from the time of conception, these fetuses cannot live more than a few minutes, even when placed in a solution like that from which they came, which is kept at the mother's body temperature and diffused with oxygen.

The first response

Studies with human fetuses delivered by Caesarean operation and placed in a solution like that mentioned have shown that the earliest functioning of receptor-effector connections appears between the eighth and ninth weeks. Stimuli applied below the neck at this time arouse no activity. However, stimulation of the face or head with a hair produces a complicated response involving the whole body. Such a response, in a fetus of about eight and a half weeks, is shown in Figure 41.

The head turns away from the stimulus, the arms move down, the rump is rotated, and the body arches away from the side stimulated. Within one to a little over two seconds, the fetus returns to its original posture. Many of the structures involved are moved, not by their own functioning, but passively through the activities of neighboring structures. Similar movements are sometimes made by a fetus of between nine and ten weeks, even though no stimulus is applied.[2] These are the so-called "spontaneous" movements. They probably result from internal stimulation of some kind.

41

Excerpts from a Moving Picture of Fetal Reaction

This fetus was probably about 8½ weeks old. It was stimulated on the face with a hair, as illustrated. The first 3 pictures in the sequence, beginning at the top, were two frames (⅛ second) apart. The third and fourth pictures were four frames apart. Observe that the hands moved down and, in the last frame shown, had almost returned to their former position. Movements of the head, rump and feet are not so clearly evident. (© by Davenport Hooker.)

Growth of the response repertoire

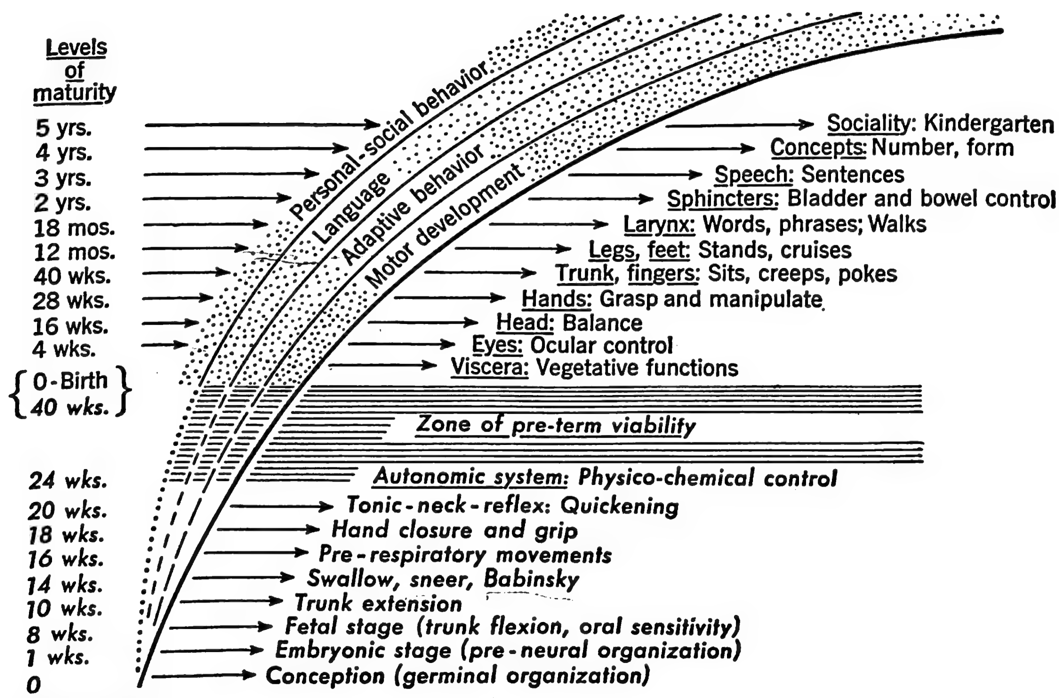
During the fourth month following conception, many new and more specific responses appear. Several reflexes exhibited by newborn babies can be aroused at this time. During this month, also, the entire body surface becomes responsive to stimulation. This greater specificity of behavior, with the possibility of arousing it by stimulation applied anywhere on the body surface, is due to growth of receptors and effectors as well as growth of their nervous connections.

The activity of fetuses during their fifth month of life is so great that the mother is clearly aware of it. Among new responses which appear at this age is the grasping reflex. Weak grasping occurs when the palm is touched.[3] Complicated reflexes involving both sides of the body also appear at this stage of development. When one foot is stimulated and responds, for example, the

opposite hand also reacts. This type of reflex, which appears in crawling and walking activities, has been called a *trot reflex*. Slow rhythmical movements, like those involved in breathing, have likewise been observed in the fifth month of prenatal life.

The sixth month brings strengthening and further complexity of reflex activities. A few new responses appear. One of these is faint "crying" upon exposure of the fetus to air.

The growth of behavior which we have sketched is due primarily to development of receptors and effectors, and of their interconnections through the spinal cord and, later, the brain stem. While the cerebral cortex is growing rapidly during the latter part of this period, its role in the integration of behavior is apparently either small or nonexistent. Its removal in some early fetuses has had no effect upon behavior. Even at the time of birth there is apparently little dependence of behavior upon functioning of the cerebral cortex. This is shown by the following facts: (1) children born without a cerebrum have normal reflexes; (2) motor abnormalities due to birth injuries to the cerebrum do not show up until some months after birth; and (3) electroencephalograms of newborn babies lack the rhythms which appear later.[4]

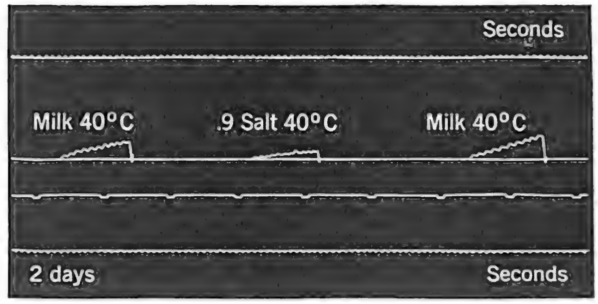


42

Trends and Sequences of Early Human Growth

Observe that the maturity levels represented here range from conception (0 weeks) to 5 years. Motor development (heavy curve) is alone very evident at early stages. But preparation for adaptive behavior (e.g., alertness, intelligence) is evident in prenatal growth. Mechanisms to be utilized in language and personal-social behavior are also laid down prior to birth. The Babinsky Reflex (14 weeks) is a spreading of the toes when the sole is stroked. Social behavior does not normally appear until four weeks after birth. (After Gesell, A., and C. S. Amatruda, Developmental Diagnosis: Normal and Abnormal Child Development. *New York: Hoeber, 1941, p. 9. © 1947 by Arnold Gesell.)*

Until the sixth month of prenatal life, the human organism is nonviable, i.e., has no chance of survival if born. The zone of preterm viability is represented in Figure 42. It ranges from 24 to 40 weeks. One will observe, from the figure, that some activities which have special functions after birth are foreshadowed in fetal activity. Swallowing and pre-respiratory movements, for example, are evident at around, respectively, the 14th and 16th weeks. Indeed the transition from prenatal to postnatal life, and beyond, is a regular one, without abrupt breaks in the sequence. This is most evident for motor development. But other forms of behavior, even language and personal-social (Figure 42), while they cannot occur prenatally, utilize mechanisms which have partially developed before birth. We shall see later (Chapter 6) that a simple form of learning can occur during the late prenatal period.



43 **Taste Discrimination in a Two-Day-Old Infant**

The bottle sucked by a two-day-old was connected pneumatically to a recording tape. This figure shows part of the record obtained. Note that the sucking pattern to sweet milk at a temperature of 40° was similar from time to time whereas the pattern elicited by salted milk was quite different. Conclusion: This two-day-old differentiates salt and sweet milk. (After Jensen, K., "Differential Reactions to Taste and Temperature in Newborn Infants," Genet. Psychol. Monog., *1932, 12, p. 423.)*

BIRTH AND AFTER

From the standpoint of psychology, the chief importance of birth is that it introduces us to new, more complex, and more intense stimulation. The world is immeasurably wider after birth than before. Moreover, it includes social as well as nonsocial stimuli. The child is now influenced, in other words, by contacts with parents, other children, and neighbors. But the fact that it is now an independent organism, carrying on its own respiratory and digestive functions, is of greater physiological than psychological interest. But birth does provide new forms of stimulation and new kinds of sensitivity. The child may, for example, now become hungry and thirsty. This was hardly possible while it was obtaining nourishment from the mother's circulatory system.

Sensitivity at birth

The sensitivity of newborn babies is gauged from behavior elicited by various forms of stimulation. For example, if the child withdraws its hand when it is touched, cutaneous sensitivity is assumed to be present; if the eyes follow a moving visual object, visual sensitivity is present; if there is a different response to red from that to green of the same brightness, color vision is present; if the sucking response is different for salty from that for sweet milk of the same temperature (Figure 43), taste sensitivity is present; if sucking differs for milk at a temperature of 40° C. and a temperature of 22° C., temperature sensitivity is present; and so on. Psychologists have systematically studied all kinds of sensitivity in human infants, and the general conclusion is that every sense is functional at, or within a few weeks after, birth. Some of these senses, however, require more intense stimulation at birth than they do later.[5]

Behavior of the newborn

The behavior of newborn human beings

may be characterized in several ways: (1) There are a large number of reflexes, most of which may be aroused prior to birth. Practically all adult reflexes are present. A few reflexes (such as the spreading of the toes to stimulation of the sole) disappear later in infancy. (2) There are a number of complex behavior patterns (such as being startled in response to certain stimuli) which obviously involve the co-ordination of several reflexes. (3) There are diffuse, generalized, or mass responses of the body. These are not easily described, and are usually referred to as mass or generalized activities to distinguish them from the more specialized reflexes and reflex patterns.[6]

Which comes first, reflex behavior or activity of the whole organism? There has been much discussion concerning this issue. Some believe that behavior is at first generalized and that specific responses (reflexes) emerge from, or differentiate out of, such diffuse or generalized patterns. Others take the view that reflexes come first and that all larger behavior patterns are combinations of these.

With a few exceptions, the evidence favors the first alternative.[7] Most behavior, both unlearned and learned, prenatal and postnatal, is at first widespread, involving many body parts. Responses of greater specificity — those narrowed down to particular parts of the organisms, as in the case of reflexes — usually appear relatively late in fetal life. Some fetal responses, however, are quite specific. Note the downward movement of the hands in Figure 41, and their return to the original position. Such a response at this age, however, does not occur separately from responses of the body as a whole. Later, it is a separate response. It may be elicited without movement of the rest of the body.

We see the same process of behavioral differentiation after birth. The baby's first efforts to crawl involve many responses that are not necessary for efficient crawling. Gradually the responses that are not needed drop out. The same is true of walking. The child spreads its feet too far apart, lifts its knees too high, flexes its knees too much, and, to aid balance, moves its arms in ways which are unnecessary to achieve efficient walking. In grasping objects, too, the hand is first used as a whole. The child "palms" the object. Later on, however, activities of the hand as a whole make way for precise finger-thumb opposition.

LOCOMOTION

Development of locomotion in human infants has been studied extensively. Two aspects have received particular attention: (1) the *sequence of locomotor development,* and (2) the *mechanics of locomotion.*

The sequence of locomotor development

The early motor development of children usually follows a similar sequence. This sequence is illustrated in Figure 44. A particular child, although it will probably follow this sequence closely, may reach any one of these stages at a greater or less age than that indicated. Some children, for example, walk as early as ten or eleven months; others not until they are about two years old. In the former case, the stages may be telescoped; in the latter, they are drawn out. Occasionally, too, a child skips one or more stages. Sometimes, for example, walking occurs before creeping.[8]

An interesting phenomenon associated with the motor sequence is control of the upper before the lower parts of the body. This head-to-tail (cephalocaudal) sequence is found in development of motility in all vertebrates.

The mechanics of locomotion

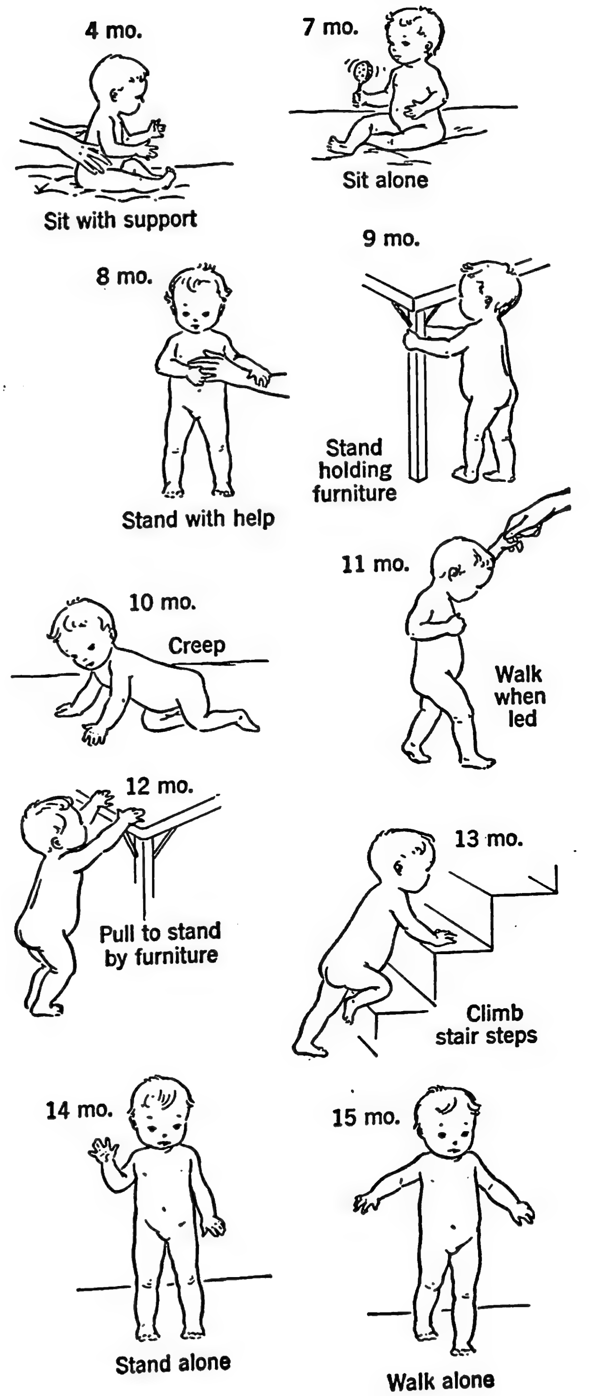
When mechanics of locomotion are considered, we differentiate between: (1) the locomotor sequence from the initial stages of

prone progression to creeping and (2) the sequence from standing to walking.

In early stages of prone progression, the abdomen remains in contact with the floor. The baby at first merely raises its head and moves its hands and feet in an inco-ordinated manner. Later, it raises its chest. The child cannot, at this stage, support its weight on hands and knees, but it moves by sliding and pivoting on the abdomen. When the crawling stage is reached, there is movement forward, but with the abdomen still on the floor. The baby's movements, at first clumsy, are co-ordinated so that an object may be approached more or less directly. Finally, the abdomen is raised from the floor, and creeping begins. From this point on, the further development of creeping usually consists in better co-ordination of hands and legs, and an increase in the speed and amount of creeping. Sometimes, however, a child straightens his legs and walks on all fours, in monkey fashion.[9]

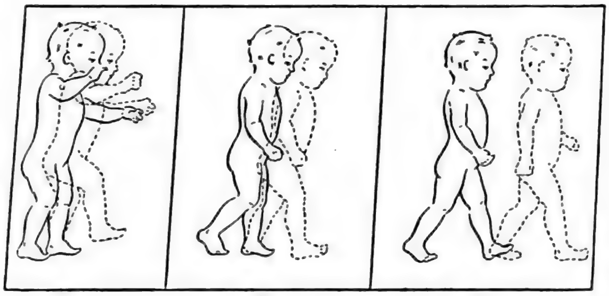
When the child stands up, his biggest mechanical problem is balance. He now has only two points of contact with a surface. These are small, the center of gravity is high, and the weight of the body relatively slight. All three factors contribute to the initial unstable equilibrium. He partially overcomes this handicap, at first, by spreading his feet. Eventually, he counteracts it by proper co-ordination of muscles.

When the child steps out, a new integration of sensory and motor functions is required. At first, as we have already noted, he keeps his feet wide apart, often walking in such a way as to lift them as little as possible from the floor. Sometimes, however, he raises his feet too high. Moreover, walking is at first flat-footed. Heel and toe progression comes later. Although, in the first stages the hands are held up and outward to aid balance (Figure 45), they are later dropped and normally flexed at the sides. The development of upright locomotion is



44

Some Stages in the Motor Sequence (After Shirley.)



45 Development of Locomotion from the Onset of Independent Walking to Appearance of an Integrated Gait

Note especially the placement of feet and hands. (A) Inception of independent walking. (B) Heel-toe progression. (C) An integrated gait. (After McGraw, M. B., "Neuromuscular Development of the Human Infant as Exemplified in Achievement of Erect Locomotion." J. Pediatrics, *1940, 17, p. 750.)*

characterized by increased speed of walking and, finally, by running.[10]

PREHENSION

Prehension is voluntary grasping. We refer to activities involved in reaching and grasping as *prehensile.* Grasping, as we have seen, is possible in prenatal life. The normal newborn child has a very strong grasp, often sufficiently strong to support the body. Early grasping activities, however, are reflex responses of the hand as a whole. They occur only when an object is placed in the hand. No reaching toward objects and voluntary grasping is evident until several months after birth.

If a baby of about twenty weeks is placed at a table top, as shown in Figure 46, and a cube is placed in a position equidistant from both hands, only fixations of the object with the eyes and random movements of the arms are apparent. With increasing age, however, the hands are brought more and more directly to the cube. Later, one hand is used instead of two. During the first half year, there is fluctuation from one hand to the other. Finally, the activity of the right or left hand predominates — usually, of course, the right.[11]

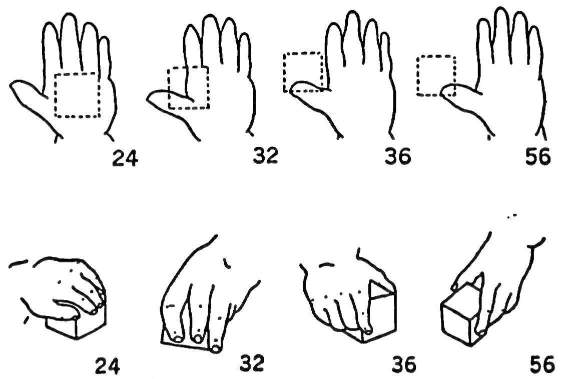
The voluntary grasping response itself undergoes a gradual change. Some steps in the sequence from reflex to voluntary grasping are illustrated in Figure 47. Note that the palming response, which involves indiscriminate use of the hand as a whole, appears first. Gradually, the fingers are opposed to the thumb. Finally, at around a year, forefinger-thumb opposition appears. This, as we have seen, is a form of manipulatory skill present to a high degree only in man.[12]

LANGUAGE

Walking, forefinger-thumb opposition, and language are the most significant achievements of infancy. All three play important

46 Testing Development of Prehensile Activity in Babies

Here the child is reaching for a small pellet placed before it by the experimenter. (Courtesy of Dr. Arnold Gesell.)



47

A Series of Steps in the Developmental Sequence of Grasping a Cube

The numbers refer to weeks of age. In the upper pictures, the relation of the cube to the palm of the hand is shown. The lower pictures show the position of the fingers in grasping. (After Halverson.)

roles in later psychological activity. Language, however, is of the greatest psychological significance, for it not only enables the child to influence others and learn from them, but it is intimately involved in his thought processes; that is, in recalling, forming concepts, and reasoning.

Gestures

Language includes gestures, speech, and writing. However, not all gestures are linguistic. They become language only when used to represent something else, such as distaste, refusal to comply with a request, and agreement. For example, the child's first grimace upon receiving castor oil is not language. It is purely reflex. But when the grimace is attached to the sight of anything or to an idea that one dislikes, it becomes part of a gesture language. Likewise, turning the head from side to side, in our society, is a language response only when it means "no"; nodding the head only when it means "yes." The child learns a gesture language long before he is able to speak; but individual children, depending upon their social contacts, learn it at widely different ages.

Speech

The first sounds made by an infant have no meaning, hence do not, in any sense of the term, constitute language. As in the case of gestures, they acquire linguistic significance only when, singly or in combination, they are used to represent objects, actions, or ideas. These initial sounds are alike in babies of all races and nations, and even in deaf babies. They are really reflex cries.

A recent intensive study of the earliest sounds made by infants demonstrates that, out of over forty distinguishable adult speech sounds,* the newborn uses only eight, five of them vowels. The vowel sound like that in *cat* comprised 90 per cent of all of the vocal utterances. In a group of forty babies under ten days old, it was the only vowel used by every baby. The other four vowel sounds, used by some, were like those in *fit, set, up,* and *food.* The consonants were *h, l* and the sound made by the pressure of breath behind the closed glottis.[13]

Cries eventually cease to predominate and sounds of which cooing is representative are increasingly evident. The babbling stage, *ma-ma, lul-lul* and so on, is well recognized. It lasts until around the end of the first year. About this time rough approximations to real words occur. Sound combinations like *mama* and *dada* develop out of babbling and are called *words* when they represent something intelligible to individuals other than the baby who makes them.

Suppose, for example, that the mother shows special pleasure to the child every time he happens to vocalize "ma-ma," a response at first apparently accidental. If the mother's attention to the vocalization occurs sufficiently often, and if the child is able to make the response voluntarily, he will

* International Phonetic Alphabet.

eventually say "ma-ma" when he hears her, when he wishes to call her to him, or, perhaps with pointing, when he wants her to leave him. The sounds "ma-ma" have ceased to be mere vocalizations; they have become speech.

The first word is spoken at an average age of about ten months. New words, all of them nouns at first, come very gradually. Toward the end of the second year there is usually a rapid spurt and new words appear daily. One study showed an average of 1 word at 10 months, 3 at 12 months, 10 at 15 months, 22 at 18 months, 118 at 21 months, 272 at 24 months, 446 at 30 months, 896 at 36 months, and 1222 at 42 months.[14] Although nouns always predominate, the other parts of speech gradually appear.

The child often uses a word under such circumstances, and in such a manner, as to suggest a phrase or sentence. "Mama," for instance, may mean not a mere naming of the parent, but "Mama come here." In such cases "mama" is really a "word-sentence." [15]

The child's vocabulary is usually fairly extensive (one hundred words or so) before he puts words together in actual phrases and sentences. About two words is the average length of phrases at around two years. By five years the average is about five words.[16]

Writing

Like gestures and vocalizations, the marks made by the child gain linguistic significance only after they represent something and can be used to communicate with others. One problem in development of writing is learning to make correct drawings (letters); another is learning what these signify. True written language is present only when the drawings represent something other than themselves and can be used to convey meaning. It frequently happens, however, that the child learns the meaning of written symbols before he can reproduce them.

SUMMARY

Duplication of cells occurs soon after fertilization. The ovum divides to form two cells, these to form four, and so on. As cells continue to multiply in this way, a spherical mass appears. Liquid enters the mass and separates certain groups of cells. Some of the cells form a fluid-filled sac in which the individual develops until the time of birth. Others give rise to the individual himself. The fluid which surrounds an individual during the embryonic and fetal stages is an important factor in development. Also important is nourishment received, somewhat indirectly, from the mother's circulatory system.

An early stage in development of the nervous system is marked by the appearance of a neural tube. The lower part of this tube becomes the spinal cord. Within the developing spinal cord are primitive nerve cells from which fibers grow toward tissues that are to become muscles. On the outside of the spinal cord develop fibers which connect sensory and motor neurons. Other cells within the spinal cord send fibers upward. These eventually carry sensory impulses toward the brain. Fibers grow from nerve cells in the brain toward lower levels of the nervous system. These fibers eventually become motor pathways. They are the channels for later voluntary movement.

The brain is first outlined as three bulbs at the head end of the neural tube. These bulbs differentiate to form the structures of the cerebrum and brain stem. The outer surface of the cerebrum is at first smooth. As the cerebrum grows in size and internal complexity, however, its surface invaginates, and many wrinkles appear. This gives added room on its surface for billions of nerve

cells that are to become the cerebral cortex. Practically all of the estimated nine billion or more nerve cells of the adult brain are believed to be present at birth. Further growth is primarily in the size of neurons, and in the nature of connections between them.

Although some of the receptors do not normally function prior to birth, most of them function when first stimulated after birth.

The limbs and vocal mechanisms are our most important effectors. Our limbs begin as small buds. Although they are well developed at birth, they must undergo further growth and training before we are able to use them effectively.

Reflex activity appears soon after receptors and muscles are interconnected by nerve fibers. Responses of human fetuses delivered by Caesarean operation begin in the third month of prenatal life. The initial response is relatively diffuse, involving the whole organism capable of responding at the time. As the fetus gets older, however, specific reflexes become increasingly apparent. By the fifth month, most of the reflexes of newborn infants are already present. Their further development until birth is primarily in strength. A few new reflexes appear after the fifth month.

Motor and language responses are among the most important of the child's activities. Development of locomotor and prehensile responses follows a rather uniform sequence, but the time of appearance of items in the sequence differs from one child to another.

Language consists of gestures, vocalizations, and drawings, which, through the processes of learning, have come to represent objects, activities or ideas, and which may be used as representative of these in communication with others.

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5 HEREDITY, ENVIRONMENT, AND MATURATION

The Human Environments • Heredity: Genes; multiplication of cells; maturation of reproductive cells; an example of inherited behavior • Environment • Heredity and Environment: The postnatal environment • Experiments with Heredity and Environment — Heredity Constant • Experiments with Heredity and Environment — Environment Constant • Maturation • Maturation of Behavior Experimentally Demonstrated: Experiments with animals • Maturation in Infants: Restriction of activity; restriction of activity and behavioral development in Hopi Indians; the development of Johnny and Jimmy; co-twin controls • Growth from Maturation and Activity Compared • Summary

WHY IS IT THAT EACH OF US BECAME A HUMAN BEING instead of a rabbit, cat, or chimpanzee? Why is it that some of us are males and others females? Why is it that we look more like our parents and close relatives than like persons who are not related to us? Why is it that our voice, walk, and other aspects of behavior are masculine — or feminine?

These questions require a twofold answer. Each of us has certain characteristics partly because he receives a particular biological inheritance and partly because he develops under particular environmental conditions.

Our biological inheritance is present from the moment of fertilization. Some environmental conditions, as we shall see, are also present, and influential, from the start. Others come into existence as the organism grows. Some environmental conditions do not appear until birth, and, of these, many do not influence development until the child is sufficiently mature to respond to them.

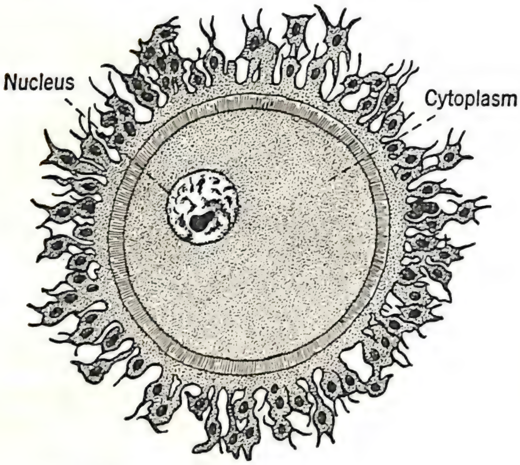
Just as each of us has a typically human heredity, despite certain variations which come from his parents, so each of us begins life, and initially develops in, a typically human environment.

THE HUMAN ENVIRONMENTS

As we shall observe in more detail later, the cellular structures which carry the hereditary determiners are surrounded by other structures and substances which constitute their environment. This environment is remarkably constant from one human being to another. Even the fluid which surrounds the developing organism in its mother's uterus is practically identical in every normal pregnancy. These early environmental conditions are thus outgrowths of our human heredity.

Most of the characteristics with which we are born (eye color, hair texture, skin color, reflexes, and so on) are produced by an interaction of hereditary determiners and prenatal environmental influences. Certain abnormalities present at birth may depend primarily upon our inheritance. Others may depend upon abnormal environmental conditions, like poor nutrition, insufficient oxygen, and cramped living quarters. Thus not every structure or response present at birth is necessarily inherited. This point is amplified later.

It is only after we are born that our envi-



48

A Human Ovum

The nucleus, cytoplasm, and surrounding membrane comprise the ovum. Follicle cells which belong to the maternal organism are shown on the outside. (After Arey.)

ronments differ a great deal. They then differ with respect to social as well as purely physical details. Through our social environments we are subjected to language, customs and other aspects of culture. Together, these comprise our *social heritage.*

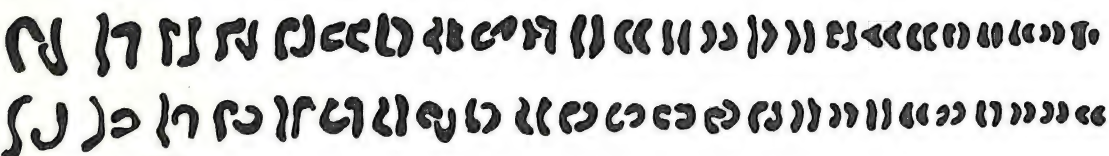
In this chapter, attention is focused primarily upon biological inheritance and environmental conditions normally present in early human development. Growth resulting from an interaction of such hereditary and environmental conditions is referred to as *maturation* — which means growing toward completeness, or fulfilling the plan of development inherent in the fertilized ovum and in the usual conditions of early development.

HEREDITY

Every cell has a nucleus surrounded by a jelly-like substance known as *cytoplasm.* The determiners of heredity are complex organizations of chemical materials within the nucleus. More specifically, they reside in nuclear structures which, because they show up when stained, are known as *chromosomes,* or colored bodies. The dark structures shown in the nucleus of Figure 48 are chromosomes.

The number of chromosomes varies from one species to another. Human beings have forty-eight. Twenty-four come from each parent. Thus all forty-eight are present at fertilization.

Microscopic studies of human body cells show that chromosomes come in pairs, as illustrated in Figure 49. Observe that females have twenty-four pairs. Males have twenty-three pairs, plus two singles. One of these, shown at the extreme right, is the Y chromosome, found only in males. It is shown with an X chromosome, of which females have a pair. The X and Y are called sex chromosomes because our sex depends upon whether we get the XX or XY combination.



49

Human Chromosomes

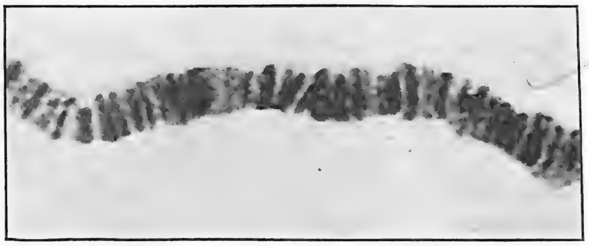
The upper set is male; the lower female. Note that the sex chromosomes (extreme right) differ in male and female. Except for this difference, males and females have similar chromosomes. (From Evans, H. M., and O. Swezy, "The Chromosomes in Man, Sex, and Somatic." Biological Memoirs Monog., *University of California, 1929.)*

Sets of chromosomes from different persons of the same sex look very much alike. Since they are chromosomes characteristic of the human race, we would expect this. But, except in the case of identical twins, the similar-looking chromosomes of different persons actually differ internally. These differences are most pronounced in unrelated individuals.

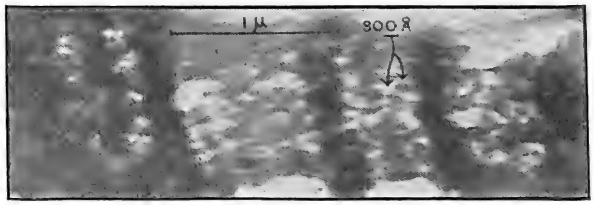
Genes

All of our innumerable inherited characteristics are represented in the forty-eight chromosomes. Thus each chromosome must carry many determiners. From this fact, and the way in which inherited characteristics, singly and in diverse combinations, are transmitted from one generation to another, geneticists long ago inferred that the chromosomes must be differentiated internally. It was assumed, in other words, that different regions of a chromosome determine different characteristics, like eye color, skin texture, and so on. Some of these regions were located and represented on chromosome maps. The hereditary factors hidden within the chromosomes were called *genes* (which means determiners). They were assumed to be "packets of chemicals" strung along the chromosome like beads on a thread or peas in a pod. But nobody had yet seen anything that might be identified as a gene.

Then geneticists discovered that the salivary gland of the fruit fly contains exceptionally large chromosomes which, when viewed microsopically, have dark and light bands throughout their length (Figure 50, A). The genes were thought to be in these bands. Now the electron microscope reveals the sort of detail shown in Figure 50, B, which represents a piece of giant salivary gland chromosome magnified 26,000 times. Observers of this, and even higher magnifications, believe that "the discrete particles" they have seen are genes.[1] One chemical constituent of genes has also recently been identified and referred to as an "hereditary chemical." [2]



A



B

50

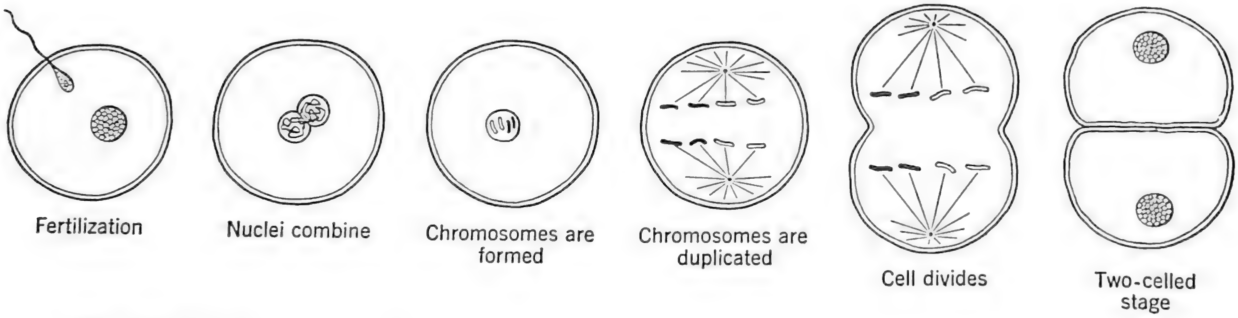
A Portion of a Salivary Gland Chromosome

This is one of the giant salivary gland chromosomes of the fruit fly. A *shows such a chromosome under a high-powered microscope.* B *is not a photograph, but an electron micrograph of a very small portion of a salivary gland chromosome. The differentiations, enlarged here 26,000 times, are believed to be, or to contain, genes. (From Pease, D. C., and R. F. Baker, "Chromosomes, Genes, and the Electron Microscope."* Science, *1949, 109, p. 9.)*

Action of the genes on cytoplasm changes the shape and other characteristics of cells. Genes, combined with internal environmental conditions, change cells from their original shape to form the great variety of cells (muscle, bone, nerve, and so on) which make up the response mechanism. Each gene may, in combinations with other genes, produce a variety of characteristics.

Multiplication of cells

When a fertilized ovum is about to divide, its chromosomes (and genes) are duplicated. A complete set is subsequently



51

Division of a Fertilized Ovum to Produce Two Cells

After the two-celled stage is reached, a similar process of division produces four cells, then eight, and so on, until billions are produced.

passed on to each resulting cell. This process of chromosome duplication and cell division is shown diagrammatically in Figure 51, where, for simplicity, only two pairs of chromosomes are represented.

52

Identical Quadruplets

These authenticated identical quadruplets (the Morlok sisters) differ in height and weight. All are of superior intelligence. They play as two sets of twins rather than as a foursome. (Acme photo.)

Since they have identical chromosomes (and genes), the cells produced by this division have the same inheritance. Sometimes, instead of remaining together as parts of a single organism, the cells separate and form two organisms. This is how identical twins originate. Siamese twins result when the separation is incomplete. Identical quadruplets, like those shown in Figure 52, are produced when the cells separate at the four-celled stage.*

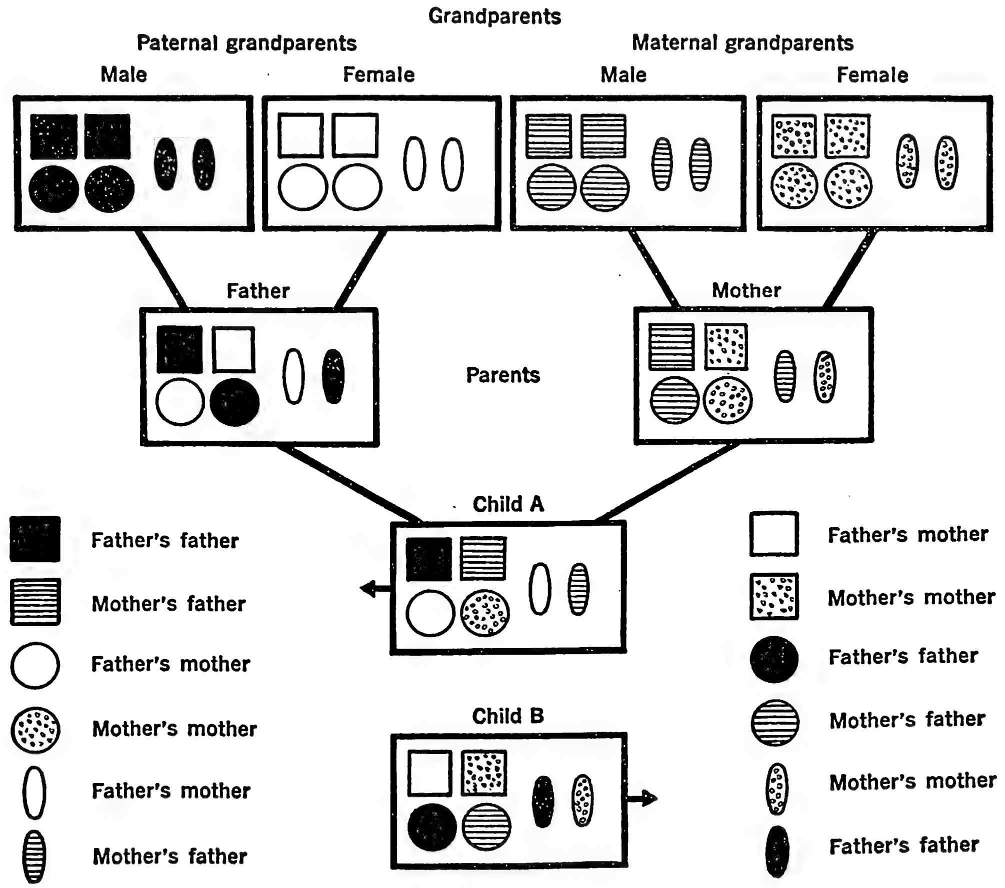
In all subsequent divisions of cells, up to the time of puberty, the chromosomes are duplicated, as we have described. Each cell has the same heredity.

Maturation of reproductive cells

At the time of puberty, cells set aside for reproductive purposes undergo a kind of division different from that described. Instead of the chromosomes being split and duplicated just prior to cell division, one member of a pair goes to each new cell. Thus, each cell has only one-half of the chromosomes, twenty-four instead of forty-eight. The ovum gets only one-half of the

* Fraternal twins develop from separate fertilized ova, rather than from the cleavage of one ovum. Thus their heredity is no more alike than that of children from the same parents but born at different times.

mother's chromosomes and the sperm only one-half of the father's. Different ova (or sperms) produced by the same individual receive different combinations of chromosomes. Which twenty-four of the forty-eight chromosomes shall go to a particular ovum or sperm is determined by "chance." Fertilization re-establishes the full complement of chromosomes. Which sperm (which set of twenty-four chromosomes from the male) will unite with which ovum (which set of twenty-four chromosomes from the female) to produce the new individual is again a matter of "chance." The laws of inheritance are laws relating to (1) the "chance" assortment of chromosomes within



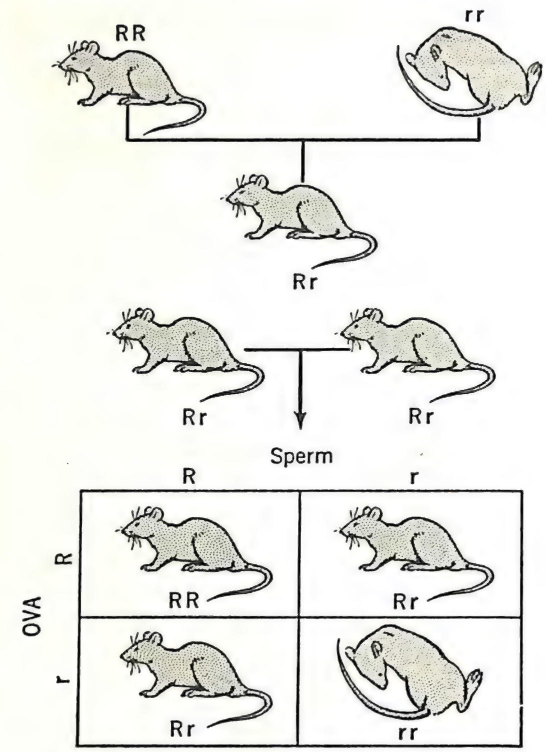
53

How Our Grandparents Contribute to Our Inheritance

Here we have, for purposes of simplicity, assumed that only 6 instead of 48 chromosomes are involved. Observe that the four grandparents may contribute different numbers and kinds of chromosomes to their grandchildren. Only two of many possible combinations are illustrated. At the time when sperms are developed, the set of chromosomes coming from the potential father's parents is a "chance" affair. Theoretically they may be all from his mother or all from his father. Likewise, the contributions of each parent of the potential mother are determined by "chance." One-half of the chromosomes must come from the mother's parents and one-half from the father's, as indicated, but how much each grandparent has actually contributed to a child's heredity cannot, of course, be known.

ova and sperm, and (2) the "chance" association of particular sperms and ova at fertilization.

During the production of sperms and ova and the process of fertilization, the contribution of each grandparent is also determined in a "chance" fashion. This contribution is illustrated in Figure 53 and discussed in the legend.



54 **Inheritance of Whirling in Mice**

This is inheritance involving dominance of one trait, viz., normal locomotion. Observe that both whirlers are doubly recessive for this trait. (Modified from Sinnott and Dunn.)

An example of inherited behavior

Suppose that a female mouse with a certain inherent defect which produces a whirling or waltzing type of locomotion is mated with a mouse which runs normally. Suppose, too, that the female whirler and the male runner come from pure stock, so far as this trait is concerned. The whirler has the genes *r* and *r*, one in each of a pair of chromosomes. The runner, on the other hand, has the genes *R* and *R*, one in each of a pair of chromosomes. Use of the capital *R* in this case indicates that running is *dominant*, and the whirling *recessive*. If the combination *Rr* should occur, the animal would be a runner. The gene *R* would dominate. Although it is transmissible to offspring, *r* would have no effect.

We mate, then, an *RR* (male) with an *rr* (female) mouse. How many different kinds of sperm, with respect to this one trait, can occur? The answer is that there can be only one kind. All sperms will carry the *R* gene. How many different kinds of ova can the female mouse produce? The answer is that all of her ova will carry the *r* gene. What combination of genes, with respect to this trait, will the offspring (hybrids) have? They will, of course, have the combination *Rr*, and, since running is dominant, they will be runners. But suppose that we now mate these mice. What is most likely to be the result?

So far as the trait under discussion is concerned, both male and female mice will have two kinds of reproductive cell. There will be *R* and *r* genes in the sperms, and *R* and *r* genes in the ova. But which sperm will unite with which ovum at the time of fertilization? There are three possible combinations: that is, *RR*, *Rr*, and *rr*. What the new mouse will become depends on which combination it happens to receive, and this, as shown by the diagram in Figure 54, is predictable only in terms of probability. There is one chance that the mouse will get the combination *RR*, to two chances that it will get the combination *Rr*, to one chance that it will get the combination *rr*. The ratio is.

$$1\ RR : 2\ Rr : 1\ rr.$$

The first possibility will produce runners

with no recessive gene for this trait; the second possibility will produce runners with a recessive gene; and the third possibility will produce whirlers. There are three chances that the mouse will be a runner to one that it will be a whirler.

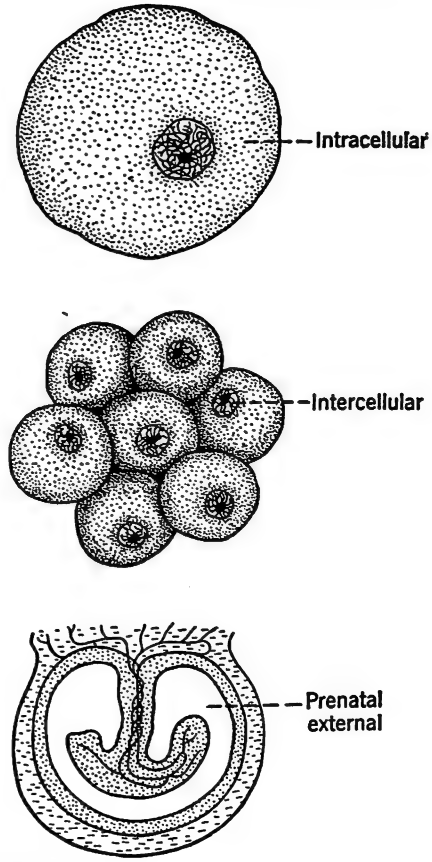
If dominance were not present, the first combination would produce runners; the second would probably produce some sort of compromise between running and whirling; and the third would produce waltzers.

This illustration is the simplest we can take. Sometimes many different genes are involved in the determination of a trait. Their possible combinations, both within ova and sperms and at the time of fertilization, are not as clearly predictable as in the present example. When we follow more than one trait at a time, like running or whirling and color, the situation is also complicated.[3]

ENVIRONMENT

Before reading the introductory statement in this chapter, you probably thought of environment merely as that which surrounds an individual — what is outside his body. But we have seen that the genes have an environment much more intimate than this. Their most intimate environment is that within the cell, the part of the cell which surrounds the chromosomes. This is known as the *intracellular environment.* It is pictured in Figure 55, top.

Somewhat farther removed is the environment of the cell as a whole: the other cells which surround it, push against it, and influence it in various ways. This is the *intercellular environment* (Figure 55, center). It represents the influence of cell upon cell. Sometimes this influence comes from a distance. The organism's glands secrete and send their products through the blood stream to cells in other parts of the body, thus influencing their development. Likewise, neural activities may produce bioelectric currents which attract and in other ways influence the development of cells in their neighborhood, but with which they are not necessarily in physical contact.



55 **The Prenatal Environments**

The intracellular *environment is primarily the cytoplasm which surrounds the nucleus. When several cells have developed, those which surround a given cell constitute its* intercellular *environment. The* prenatal external *environment comprises the liquid which surrounds the embryo (or fetus) as well as oxygen and other requirements brought to the organism through the umbilical cord.*

Then there is the external environment of the organism before birth — its external prenatal environment (Figure 55, bottom). This includes the amniotic fluid which surrounds the individual, the food and other substances

coming to it from the mother's blood stream, and pressures exerted upon it through surrounding tissues.

After birth there is the broader external environment with its immense variety of physical and social contacts. This is what we customarily think of as the environment.[4]

HEREDITY AND ENVIRONMENT

Some babies are born with physical and psychological abnormalities which depend almost entirely on defective heredity. Others are born with similar abnormalities, but which in their case are determined almost exclusively by a defective intracellular, intercellular, or prenatal external environment. A study of such cases suggests the respective parts played in prenatal development by hereditary factors and environmental conditions.

Hereditary abnormalities seldom occur in isolation. They crop up here and there among related individuals. These anomalies occur, too, in related persons with different mothers, which would mean different prenatal environments. Some examples of such hereditary defects are the "lobster claw," which appeared in a man and both of his children; the absence of hands and feet, which happened in a father and six out of twelve of his children; and idiocy, which has been found repeatedly through generation after generation of certain families.[5]

Abnormalities resulting from defective prenatal environments are isolated occurrences. They appear in related individuals no more often than in those who are unrelated. In many instances, the environmental defect is apparent. Here, for example, is a boy whose arm is withered because the umbilical cord twisted around it during the fetal period. Here is a physical monstrosity whose prenatal quarters were too cramped, or who maintained during the fetal period a position not conducive to normal growth of certain structures.

If the mother's blood stream does not supply enough calcium, abnormalities of the skeleton appear. If her blood sugar is too high as a result of diabetes, the pancreas of her fetus may work excessively. This excessive functioning may continue at birth, reducing the blood sugar of the infant so much that, unless special treatment is given, it dies from an insufficiency of glycogen (hypoglycemia).

Many cases of abnormal head and brain development are believed to result from improper prenatal conditions — perhaps chemical inadequacies of the mother's blood. Head injuries at birth, either through prolonged pressure on the head during a difficult labor or from instrumental delivery, often result in feeblemindedness, epilepsy, and other defects. All defects produced in these ways are, of course, environmental. Heredity has nothing whatsoever to do with them.

Sometimes, too, there is a disturbance of intracellular and intercellular conditions. Such disturbances are at times hereditary, in which case they run in families. Quite often, however, they are due to some deviation in the extremely complicated intracellular and intercellular relationships. When the normal sequence of these relationships is interfered with, the baby may be born with marked physical defects. It may, for example, have a harelip, missing body parts, slits in place of ears, extra limbs, or be joined, as in Siamese twins, to another individual. The two-headed baby born in Russia several years ago is possibly another example. Some babies are born without a cerebellum, some without a cerebral cortex, and others with parts missing almost anywhere in the nervous system.[6]

Environmental changes prior to birth normally follow the same sequence in all human beings. By contrast with the constant hereditary factors, prenatal environmental conditions are variable. The intracellular, intercellular, and prenatal external environ-

ments are constantly changing. But the changes follow a sequence which is alike for all normal human beings. In every normal human embryo or fetus of the same age, these environments are quite similar. The fact that they vary with age rather than with the individual shows that they arise from the similarities rather than from the differences in heredity. They are laid down under the influence of human genes. Despite differences in our genes, we do have the same number of genes and genes specialized for the production of the same basic structures and conditions of early growth. In other words, just as we have genes which contribute to the production of eyes, ears, and so on, we have genes which contribute to the production of similar intracellular conditions, similar dominance of certain cells over other cells, and a similar amniotic sac, placenta, and so on.

The only environmental conditions before birth which are not in some way influenced by hereditary factors are the more or less accidental ones already mentioned — like deviations in cellular growth, restrictions within the uterus, and insufficient nutrition provided through the mother's blood stream.

The postnatal environment

The external environment after birth is extremely variable, and unrelated to the sort of genes which the individual has. No two human beings, even living in the same home and going to the same school, have the same environment. Geographically and socially their environment may seem the same. From the standpoint of its effect on their development, however, it may be quite different. Different individuals within the same environment meet different people and are influenced differently by the same people. They develop different interests and attitudes, and they identify themselves with different groups — religious, political, and recreational.

The fact that the postnatal environment is so variable and its effects so unpredictable makes it difficult for us to determine, with any high degree of assurance, the relative influence of heredity and environment on postnatal psychological development.

Every one of us is a product of both heredity and environment. We could not develop without genes, and the genes could have no effect without normal surrounding tissues. But is the difference between Mary Brown and Jane Smith due to a difference in their heredity, or in their environment? Unless they are identical twins, with different names, as in some cases to be mentioned shortly, they have a different heredity; and some of the difference between them is attributable to this. They certainly have somewhat different environments, even if living in the same home. And part of the difference, especially in psychological characteristics, is attributable to this. The difference, therefore, between two or more individuals is normally attributable to both heredity and environment.

Which is more important in producing these differences — heredity or environment? The answer depends upon what traits are under examination. Any difference in the appearance and other physical characteristics of Mary Brown and Jane Smith at birth is due primarily to their different genes, for it is probable that their environments before birth were similar. Even after birth, the difference in their environments would produce only superficial differences in physique. But how about traits like intelligence? One may be much brighter than the other. Here again, the difference in their genes may be important, but we cannot be as sure as in the case of physical traits.

The only scientific procedure that can be used in determining the relative influence of hereditary factors and environment on physique, intelligence, personality, or other characteristics is to hold heredity or environment constant while the other is varied. The

possibility of carrying out such experiments with human beings is limited. We cannot mate persons of known heredity so as to control the inheritance of their offspring as, for example, we can mate mice or rats. Nor can we subject human beings to a constant environment, because what appears to be the same environment is not psychologically the same.

EXPERIMENTS WITH HEREDITY AND ENVIRONMENT — HEREDITY CONSTANT

Nature has provided us with some help in holding heredity constant by occasionally producing identical twins. Normally, these are reared together in the same home and, while their environment is not psychologically the same, it is more similar than in the case of individuals not so intimately related. Is the physical and psychological similarity of identical twins due to their identical heredity, their similar environment, or both? We cannot vary their environment, merely to see what effect this will have. But again, nature, or perhaps we should say society, has come to our aid; for identical twins are sometimes adopted into different homes and localities.

Take, for example, Richard and Raymond, pictured in Figure 56. Richard was adopted at the age of one month by a truck farmer. His foster father moved from one job to another, and Richard attended many different schools. Raymond, his identical twin brother, was adopted at the age of fourteen months by a physician. His home and school environments were superior to those which surrounded Richard. When the two boys were ten years old, they looked like duplicates, which is what one might expect from what has been said about inheritance of physical traits. In I.Q. (intelligence quotient) the two boys were also, despite their widely different environments, remarkably similar. The I.Q. of one was 106, and that of the other 105. In personality traits, however,

56

Richard and Raymond

(From Newman, H. H., F. N. Freeman, and K. J. Holzinger, Twins: A Study of Heredity and Environment. *Chicago: University of Chicago Press, 1937, p. 212.)*

there were marked differences. On some of the tests of personality, the boys differed by from fourteen to twenty-seven points. Their personalities, considered as a whole, probably were much more alike, however, than those of individuals differing in heredity.

Nineteen such pairs of identical twins reared in different environments have been tested. In appearance and other purely physical characteristics, they are practically duplicates. The difference in their I.Q.'s, however, varies between one and twenty-four points. Personality traits are sometimes very much alike and sometimes very differ-

ent. These differences are usually much wider than in the case of I.Q.

The average difference in the I.Q.'s of identical twins reared together is about five points. In identical twins reared apart, the difference is around eight points. The difference of five points between identical twins reared together is small compared with the average difference of approximately nine points which exists between fraternal twins reared together. It is, of course, much smaller still compared with the average difference in I.Q. existing between pairs of unrelated individuals selected randomly.

Identical inheritance thus makes individuals very much alike, not only in physical traits, but also in intelligence. They tend to be alike even when reared in widely different environments.[7]

EXPERIMENTS WITH HEREDITY AND ENVIRONMENT — ENVIRONMENT CONSTANT

Here we must take an animal experiment, for, as already suggested, no two human beings live in the same environment or react in the same way to the same aspects of their surroundings.

One hundred and forty-two white rats were each given 19 trials in an enclosed alley maze (see page 138 for a picture of a similar maze). The number of entrances into blind alleys (errors) for each rat was determined. The smallest number of entrances was 7, and the greatest number 214. Rats making very few errors were designated *bright*, and those making many errors were designated *dull*.

Keeping the environment (food, lighting, caging, temperature, and so on) constant, the experimenter bred the brightest rats in each generation with each other. Likewise, he bred the dullest with the dullest. After following this procedure for seven generations, two races of rats — a bright and a dull — were developed. The situation the investigator had at the beginning and the one he had after seven generations of selective breeding are illustrated in Figure 57.

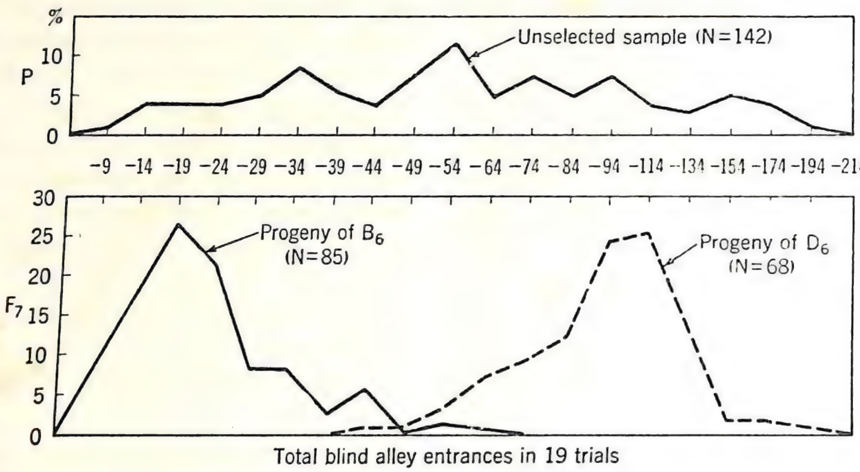
At the beginning, the rats were distributed so that most of them made scores in about the middle of the two extremes. After seven generations, however, there was a bimodal distribution — a distribution in which many rats (the bright) made low error scores, and many other rats (the dull) made very high error scores. Few animals had ability in the middle of these extremes. Selective mating was continued through the eighteenth generation, but without producing any greater difference than that indicated.

Bright and dull rats were then mated. What the investigator obtained in the progeny of this cross and in a further cross between the extremes of this group is illustrated in Figure 58. One can see that mating bright and dull rats, in both instances, produced a distribution much like that with which the experiment began. There were now few bright and few dull rats. Rats of intermediate ability predominated.[8]

In the same environment, therefore, marked differences in learning ability were produced by selective breeding, which means, of course, selecting genes.

In these two sections on experimental studies of heredity and environment we have seen that, when heredity is held constant and environment varied, the variations in environment produce differences in psychological characteristics; and that, when environment is held constant and heredity varied, the variations in heredity also produce differences in psychological characteristics. Since the same subjects and the same psychological processes were not involved in these two types of variation, we are not able to say how much difference was produced by one type of variation as compared with the other.

There is a strong suggestion, however, that larger individual differences can result from hereditary variations than from environmental variations. The differences between



57

Inheritance of Maze Learning Ability in Rats

The upper figure is to be interpreted as follows: In the parent (P) generation, consisting of 142 rats, the number of errors made in 19 trials ranged from 5 to 214. The intermediate number of errors was made by around 12 per cent of the rats. Smaller percentages of rats made the successively lower and successively higher number of errors. The lower figure represents the seventh generation in which the dull (large number of errors) were mated with dull, and the bright (small number of errors) were mated with the bright. It shows two races, a bright and a dull, with slight overlapping near the center of the error range. (From Tryon, R. C., "Genetic Differences in Maze-Learning Ability in Rats." 39th Annual Yearbook, *National Society for the Study of Education, p. 113.)*

rats and men are due almost entirely to the differences in their heredity. The differences from rat to rat and man to man, however, are partly hereditary and partly environmental in origin. Heredity plays a predominant role, no doubt, in producing differences in physique. Extreme variations in intelligence — like the difference between brightness and dullness — are most likely hereditary in origin. Smaller differences in intelligence, on the other hand, are sometimes attributable to heredity and sometimes to environment. This will become more clearly apparent in the chapter on intelligence.* In the chapter on personality,† moreover, it will be evident that both heredity and environment contribute to differences in personality traits, but that environmental variations produce larger differences in personality than they do in the cases of physique and intelligence.

MATURATION

Structure and behavior are said to result from maturation when their development depends solely upon conditions which characterize the race. Maturation in man depends upon the existence of human genes and human intracellular, intercellular, and external prenatal conditions. The genes, as we have already seen, play an important role in producing such environmental conditions.

Because the early environmental conditions play a role in development, it would not be correct to say that any structure or function which matures is inherited. Nevertheless, these environmental conditions are so

* See Chapter 22.

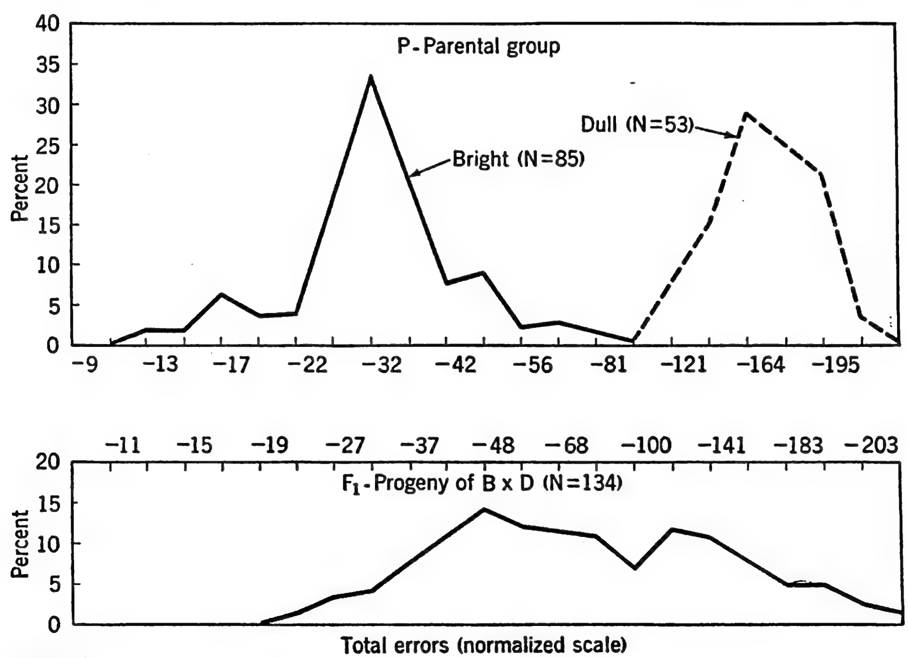
† Chapter 24.

intimately related to our racial heredity — our typically human heredity — that inheritance plays the major role in maturation.

Even after birth, mechanisms which started earlier continue to develop. The intracellular and intercellular conditions, as well as the genes, are still operative. Thus, maturation occurs after birth as well as before. The chief influence of the postnatal environment on maturation is to accelerate it (as sexual maturation is accelerated in some climates) or retard it (as sometimes happens when nutrition is inadequate for normal development).

Development resulting from maturation is to be contrasted with that which depends on stimulation and response, or on the activity of receptor, neural, and effector mechanisms. That you have a biceps muscle depends on maturation, but its size in you as compared with its size in another, especially if you have exercised it a great deal more than he has, is not due to maturation. That you have a brain which is typically human depends on maturation; but your habits and your knowledge, which are represented by modifications of the brain, are not due to maturation. They develop as a result of stimulus-response activities involving the brain — as a result of how your brain is used. Habits and knowledge are learned, acquired. Some of us have certain habits and certain information which others do not have. These developments are thus individual rather than racial. Anything which depends on maturation, however, is present in every normal member of our race.

This does not mean that there is no rela-



58

The Effect of Mating Bright and Dull Rats

Observe that the bright rats had error scores ranging from 9 to around 80, while the dull rats had error scores ranging from around 80 to around 200. Very few rats had scores ranging from 30 to 100. In a cross of bright and dull rats, however, most of the rats had scores in this intermediate range. (From Tryon, R. C., "Genetic Differences in Maze-Learning Ability in Rats." 39th Annual Yearbook, *National Society for the Study of Education, p. 115.)*

tion between maturation and learning, for what we learn often depends on how mature we are. You cannot teach a newborn child to walk, however much stimulation and help you provide, but you may teach it to suck at the sight of a bottle. You cannot teach a child of six months to pick up a pellet with forefinger and thumb, but you may teach it to lift the hinged lid of a box. And you cannot teach a one-year-old the multiplication table, however much you try, but you can teach it to bring objects nearer by pulling on the string attached to them.

The point can be illustrated further by reference to an experiment in which an infant chimpanzee, Gua, and an infant child, Donald (Figure 59), were reared in the same home environment and treated in the same way, even to the extent of kissing and similar endearments. One aim was to see how much the chimpanzee would be humanized by a human environment. An interesting outcome of the experiment was that, in certain respects, Gua was "humanized" earlier than Donald, who was two months older. In learning to skip, co-operate with her foster parents, obey requests, kiss to "make up," open doors, anticipate her bowel and bladder needs, eat with a spoon, drink from a glass, and understand such expressions as "kiss-kiss," "come here," "shake hands," and "bad girl," Gua was ahead of Donald. She learned faster than Donald because she was more mature. Although

59 **Donald and Gua, Human and Chimpanzee Infants Experimentally Reared Alike**

This upright form of locomotion, which occurred even when Gua's hand was not being held, is not found normally in chimpanzees. It is one activity which Gua learned as a result of her close association with human beings. Both infants were dressed alike, ate alike, slept in similar beds, played with the same things, and were treated alike in all important respects. (From Kellogg, W. N., and L. A. Kellogg, The Ape and the Child. *New York: McGraw-Hill, 1933, p. 275.)*

younger than Donald, the chimpanzee was ahead of him both physically and psychologically. However, a chimpanzee reaches the upper limit of chimpanzee maturity much faster than a human being reaches the upper level of human maturity.

Even at the early ages when Gua surpassed Donald in many things, Donald surpassed Gua in others. At fifteen months, Donald surpassed the chimpanzee in almost everything but strength. The experiment was terminated when Donald was nineteen months old and Gua sixteen and one half months old.[9]

Two outcomes of this experiment are especially relevant to our discussion of the relation between maturation and learning. The first is that Gua, although of an inferior race, was superior in certain respects to the child — superior because of greater early maturity. The second outcome of interest to us here is that Donald, even with his relative immaturity, could learn certain things — like speaking — which Gua, without special training, could not learn, regardless of how mature she became.* From the standpoint of evolution, men are more mature than chimpanzees, and even a human child soon becomes superior in learning ability to the most mature ape. The superiority of human maturity as compared with ape maturity is, of course, chiefly dependent upon the difference in inheritance.

The clearest instance of development resulting from maturation is growth of structures prior to the time at which they function. Basic sensory structures result solely from maturation. The structures of the eye develop even when there is no visual stimulation and no visual activity. Nerve fibers grow out to, and make connections with, sensory and motor structures, even though no nerve impulses are traversing them. Likewise, the muscles and their supporting structures grow to the point where they approximate normal proportions and interrelations long before movement occurs. If one wishes a good illustration of structural maturation after birth, sexual development provides one, for development of sex glands and of secondary sex characteristics does not depend upon sexual activity.

The earliest responses clearly result from maturation. Sensory, neural, and motor structures must develop before activity can occur. When stimulated for the first time, these structures function in the only way possible. Their functioning under such circumstances is due to maturation alone.

Various fetal reflexes result solely from maturation. Two of these, the knee jerk and the pupillary reflex, clearly illustrate maturation. When stimulation is first applied to the patellar tendon, the foot kicks forward. Likewise, when light first strikes the eye, the pupil gets smaller.

Even after structures have begun to function, further development is not due entirely to activity. There is good evidence, from experiments with animals and human infants, that maturation alone accounts for some early postnatal structural and behavioral growth.

MATURATION OF BEHAVIOR EXPERIMENTALLY DEMONSTRATED

There has been a large amount of research on maturation of behavior. While most of this has, for obvious reasons, been done with animals, there have been a few significant observations on children.

Experiments with animals

Research on development of swimming behavior in salamander and frog tadpoles

* A chimpanzee has now been trained to say three words (*cup, mama,* and *papa*). A prolonged period of special training was necessary. Like Gua, this chimpanzee was reared by human "parents." Hayes, K. J., and C. Hayes, *Vocalization and Speech in Chimpanzees* (1950). A 16 mm. sound film distributed by Psychological Cinema Register, State College, Pa.

has yielded conclusive evidence of behavioral maturation. The question to be answered in this research may be stated as follows: "If an activity is prevented until after the normal time of its appearance, will the response mechanisms continue to develop in such a manner as to make this activity possible when the first opportunity for its stimulation is given?" As far as tadpoles are concerned, the answer is affirmative.[10]

A large group of salamander eggs was separated into two groups. After head and tail buds appeared, but before any movements took place, one group was placed in a solution of chloretone, a drug which does not interfere with structural growth, yet prevents all movement. The other group was placed in ordinary tap water, which is the normal medium for development.

Tadpoles living in tap water went through the usual sequence of tadpole development. They made movements of the head and trunk, they curled up to form a C, and finally, by reversing the movement of the body before the C had been completed, formed an S. After forming an S, they made the opposite (Ƨ) reaction. This double S reaction is their normal swimming pattern. When it occurs sufficiently often and with adequate vigor, it enables the tadpoles to rise from the bottom of the dish and move rapidly through the water. While these developments occurred, the drugged animals were motionless.

After tadpoles reared in tap water had been swimming very actively for five days, the drugged animals were removed from the chloretone and placed in tap water. Within six minutes some of these moved in response to stimulation. Within a period of thirty minutes, all were swimming in the typical tadpole manner, although perhaps not quite so adequately as tadpoles with previous practice.[11] Whereas it normally requires several days to progress from the first movements to the swimming response itself, the previously inactive animals required but thirty minutes. Apparently their swimming mechanisms were developing, even though not used.

Was the period prior to swimming due to aftereffects of the drug? Was it a period during which rapid learning occurred? The answers to these questions were provided by a control experiment in which animals reared in tap water until they were swimming normally were placed in chloretone. These animals, of course, became motionless. After twenty-four hours of inactivity they were removed from the chloretone and placed in tap water. Like the control animals of the previous experiment, these tadpoles, which had already been swimming, required up to thirty minutes before swimming again. It is thus clear that the delay in swimming of drugged tadpoles was due to wearing off of the effects of the chloretone, not to learning.

The only possible conclusion is that the swimming of tadpoles results from maturation, from growth of sensory, motor, and nervous mechanisms to the point where, without any previous activity, they function as soon as appropriate stimulation is provided.

Further evidence of maturation is to be found in experiments on birds, rats, and human infants. The normal vocalizations of birds do not depend upon training or imitation. In one experiment, canaries were reared in separate soundproof cages, so that they could not hear the songs of their species. At about the usual time for these songs to appear, however, the isolated canaries began to sing them. The obvious conclusion is that singing the typical canary songs is dependent upon maturation rather than learning.[12]

Rats were separated from members of the opposite sex until the time of puberty and then given an opportunity to mate. Their mating behavior was indistinguishable from that of rats reared in contact with animals of the opposite sex. Since they had no previous opportunity to practice this response and

had never seen it performed by others, it was clearly due to maturation.[13]

MATURATION IN INFANTS

Investigations on maturation in human beings are difficult, if not impossible, to carry out in a manner as straightforward as with animals. One cannot prevent all activity. Nor can one isolate human beings as one does tadpoles, rats, or canaries. The closest approximation to such controls with human subjects is provided in an experiment in which infant fraternal twins were reared from the age of one month to the age of nine months under conditions of relative restriction.[14]

Restriction of activity

The infants were prevented from reaching, sitting, and standing until after the time at which these activities normally occur. Restriction consisted in keeping the child on its back, having the bedclothes tucked in so tightly as to prevent withdrawal of the hands, and preventing any social stimulation which might encourage reaching, sitting, or standing.

None of the three responses occurred in either child when appropriate conditions were first provided. Although reaching for a dangling ring normally occurs by the 200th day, neither child reached for the ring when it was presented for the first time at the 245th day. Thirteen days elapsed before reaching began. Sitting alone normally occurs before the 245th day. The twins were given their first opportunity to sit at the age of 262 days. However, one did not sit alone until the 298th day. The other sat alone on the 326th day. Standing with help is normally present by the 270th day. Nevertheless, it was not present in these infants when they were first tested at 364 days. Within three days, however, they were standing with help.

The investigators pointed out that, even after they gave the children an opportunity to reach, sit, or stand with help, no encouragement or training of any kind was provided. The activity which preceded reaching, sitting, and standing with help was *autogenous* — that is, initiated by the children themselves. Evidence for maturation resides in the fact that, although the responses did not appear immediately when there was opportunity for them to do so, they did appear within a relatively short time. For example, three days was sufficient to make up for the weeks of activity which normally precede standing with help. This is doubtless because, although activities which normally precede standing were prevented, the receptors, bones, muscles, and nervous mechanisms called for in standing were undergoing normal development. All that was necessary for their appropriate function was a little practice and perhaps confidence in using them.

Restriction of activity and behavioral development in Hopi Indians

Another interesting study of the effect of restricted activity on development of behavior was made among Hopi Indians.[15] As soon as a Hopi child is born, it is bundled up in a cotton blanket, which keeps its hands extended at the sides. The child is then bound to a stiff board. Pieces of cloth pass around the bundled child and the board, in such a manner as to prevent flexing of the legs, bringing the hands to the mouth, putting feet in the air, and even turning the body. A similarly bundled Navaho child is shown in Figure 60.

For the first three months, the infant is released from this position only about one hour daily while being cleaned and bathed. After three months, increased freedom is given.

In spite of the enforced extension of the

60

A Baby Bundle

Babies bundled up in this fashion, so that they cannot reach for objects, sit up, creep, or walk, are nevertheless not handicapped in motor development. At the normal walking age, for instance, they walk as do others who have not been so restricted. (Courtesy of American Museum of Natural History. © Mischler and Walker.)

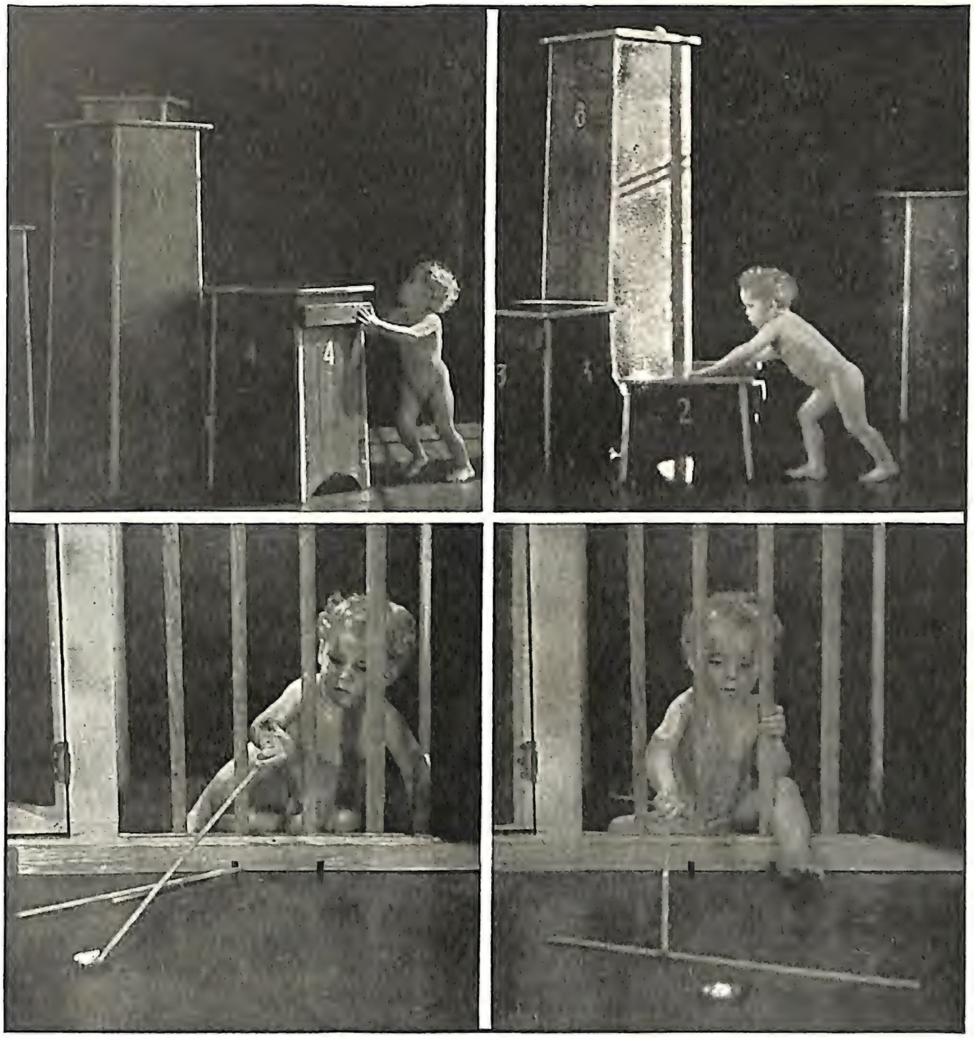
limbs, the young Indian infant, when freed from his bindings for the bath or for the changing of bedding, takes the usual flexed position. Although his hands are held downward, perhaps twenty-three hours in twenty-four, when he is at liberty, he puts them to his mouth and carries objects to his mouth as do white babies. He reaches for objects and handles them at approximately the same time as do white children. He reaches for his toes and puts his toes in his mouth. Sitting, creeping, and walking follow in the usual sequence.[16]

While the orthodox Hopi method of cradling infants is that described above, the contact with white culture has led many Hopis to cradle their infants as white people do. This difference in the practice of cradling in the same race, and among people who are, in other respects, of similar culture, provided "experimental" and "control" groups for a study of maturation. The average age of walking was tabulated for 63 children reared in the orthodox way and 42 reared in the manner of white infants. Children who were bound to the boards during infancy walked at an average age of 14.95 months. Those reared without binding walked at an average age of 15.05 months. The difference is not significant. It is obvious that prevention of activity incident to cradling in the orthodox manner had no retarding effect on motor development.

The development of Johnny and Jimmy

Another method of obtaining information on the relative influence of maturation and activity in early development is to train one group in certain activities and not to train a comparable group, then compare the performance of each. If the trained group is ahead of the other, its gain is attributable to practice. If both groups are alike in final performance, the practice has been without avail, and the development is attributable to maturation.

One experiment of this nature involved twins thought at the time to be identical, but later found to be fraternal. One twin (Johnny) was given extensive practice in a wide variety of activities — some characteristic of the race (like crawling, standing, and certain reflex activities) and some found only in individuals (like swimming, skating, and climbing inclines), while the other (Jimmy) received no practice. During the early part of the experiment, while his brother was getting practice several hours daily, five days a week, this child was merely lying in his crib behind a screen. The experi-



61

Johnny and Jimmy

Reaching rewards by arranging pedestals and by using sticks. (From McGraw, Myrtle B., Growth: A Study of Johnny and Jimmy. *New York: Appleton-Century-Crofts, 1935.)*

ment lasted for almost three years, with certain check-ups at later age levels.

Johnny and Jimmy, whose pictures appear in Figure 61, were much alike in development of all racial activities, despite the difference in their practice of these. This suggests, of course, that maturation without practice produces these activities. For individual activities, however, the trained twin was far ahead of the other, as one might expect. When given an opportunity to learn these activities, however, Jimmy usually acquired them much more easily than they were acquired at an earlier age by Johnny. In other words, while his maturation did not produce these activities, Jimmy's relatively greater maturation at the time the activities were learned aided his learning.

Jimmy was more timid and less co-operative than Johnny. The investigator attrib-

utes this to the effects of early training on Johnny. It is possible, however, that this difference had some inherent basis, for the twins, as already mentioned, were not identical. If they had been identical, it could definitely have been attributed to training.[17]

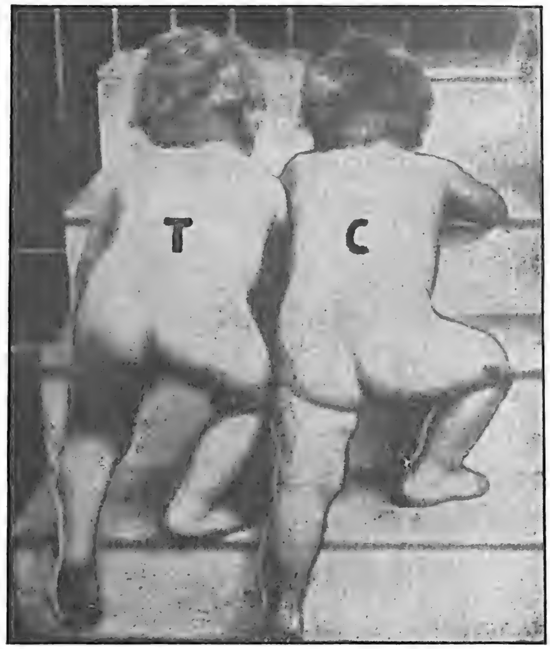
Co-twin controls

Among several other experiments on maturation in infants are those involving comparison of the growth of behavior in identical twins, when one was allowed to develop with no unusual attention, while the other was given special training. The reason for using identical twins is that, since they have identical heredity, they will tend to mature at the same rate. Thus, any difference in their development may be attributed to factors apart from maturation.

In one co-twin control study, the identical female twins shown in Figure 62 served as subjects. The aim of this investigation was to discover whether training of one twin (T) in such activities as stair-climbing would later give her an advantage over the control, or untrained twin (C).

Twin C had no chance to climb stairs until she reached the age of 53 weeks. Twin T, on the other hand, was trained in stair-climbing from the age of 46 weeks. When first tested at 46 weeks, T did not climb. She acted passively, and was helped on all five steps. After four weeks, however, she was climbing without assistance. By the age of 52 weeks she climbed the five steps in 26 seconds.

When C was first placed in the staircase situation at 53 weeks, she climbed the stairs unaided, but required 45 seconds. At 55 weeks, after two weeks of practice, C was climbing the stairs in 10 seconds. Thus, at this age she was superior to T, who had received three times as much practice, but had received it at an earlier age. C was, of course, three weeks older than T had been when last tested.



62 **Stair-Climbing of Identical Female Twins**

T *(the trained) and* C *(the control) twins are shown at the age of 79 weeks. Note the similar postures. (Courtesy of Dr. Arnold Gesell.)*

All studies like the one we have described have shown a strong influence of maturation, especially in reflex, manual, and locomotor activities characteristic of the race. These activities develop in the untrained almost, if not exactly, as early as in the trained twin. Activities which do not necessarily appear in all human beings — skating and climbing, say — are influenced by maturation only in that they are learned more quickly by older than by younger infants. The older infant has an advantage due to his greater sensory, neural, and motor maturity.[18]

GROWTH FROM MATURATION AND ACTIVITY COMPARED

Maturation involves multiplication of cells It also involves their differentiation and increase in size before the time at which they

begin to function. The experiments discussed above demonstrate, furthermore, that maturation underlies some development even after normal functioning begins.

What kinds of change are wrought by functioning, by exercise, or activity? Everybody knows that exercising a muscle increases its size and strength. Not so widely known, however, is the fact that this increase in size results merely from enlargement of muscle fibers already present; that no new fibers are thereby produced.[19]

It has been claimed that neural activity affects the growth of neighboring nerve fibers. Dendrites, for example, are said to grow from primitive nerve cells toward regions of neural activity. According to one theory, the dendrites and cell bodies are positively attracted by electric currents associated with activity.[20] There is no evidence, however, that new nerve cells are produced by neural activity.

Maturation apparently provides the basic structures of the organism and is responsible for some of their early growth. Activity, on the other hand, influences the further growth of structures already present. It increases the size of muscle fibers, the nature of nervous connections, and possibly the growth of other parts of the response mechanism.

SUMMARY

Our biological inheritance is determined by the genes, small packets of chemicals located in the chromosomes. We get a set of twenty-four chromosomes from each parent. There are thus forty-eight in the cell with which our life begins. These are duplicated during cell division so that every cell in our body except the reproductive cells (ova or sperm) has the same hereditary factors with which the original cell began. Ova and sperm have one half the original number of chromosomes. In formation of these cells, the chromosomes do not split to form duplicates, but one of each pair goes to a different cell.

Although every individual has the forty-eight chromosomes which characterize the human race, each differs in the constitution of these. All have the same number of genes, but the genes differ in certain respects. This variation plays a large role in making human beings differ both physically and psychologically from one another.

We are products of environment as well as heredity, for the genes do not function in a vacuum. They are surrounded by cytoplasm which they modify without themselves changing. In modifying cytoplasm, they change their own environment from time to time. This is the intracellular environment. Genes, by playing a role in the duplication and differentiation of cells, contribute to development of the intercellular environment, which again places limitations on their further functioning. The genes also play a part in development of the amniotic sac, placenta, and other external structures. The amniotic fluid in which the child grows, and the mother's blood stream from which it gets nourishment and through which it secretes waste products, are part of its external prenatal environment. These prenatal environments are similar in all normal human beings, but unusual conditions sometimes arise and markedly alter them. In this event, the individual, if it lives, is usually a monstrosity of some kind. When such abnormalities run in families, they are attributable to heredity. When they occur sporadically, however, they are usually due to defective prenatal environments or to accidental disturbances of cellular growth and differentiation.

The postnatal environment is never the

same, psychologically speaking, for two human beings. We not only respond to different aspects of our surroundings, but we respond to the same aspects in different ways. Some of the differences in our intelligence and personality are attributable to differences in our external environments after birth. This is demonstrated when identical twins are reared in widely different environments. Differences produced by variations in environment are usually greater in the case of certain personality traits than in the case of I.Q.

Experiments on rats have shown that hereditary variations in the same environment produce marked differences in learning ability. In the rat, at least, these differences are very much larger than one could produce by environmental variations. Man is more responsive than the rat to variations in his environment, so variations may produce larger changes in intelligence and personality than would be possible in the rat. It is probable, however, that very wide differences in human intelligence (as the difference between brightness and dullness) are attributable largely to heredity. More will be said about this in the chapter on intelligence.

Maturation is growth resulting from the interaction of genes and early developmental conditions which characterize the race. This growth does not depend on exercise. Development of structures before the time at which they function is the clearest example of maturation. Behavior which appears when these structures are first activated is, of course, due to maturation.

Experiments on animals and children have demonstrated that certain activities which appear after birth are similarly independent of exercise. Even where activities do not result from maturation, but must be learned, they are often learned more readily by the more mature organism.

The basic structures and functions of the organism, those characteristic of the race, result from maturation. Activity, on the other hand, produces no new structures. What it does is to influence the size, interconnection, and functioning of structures already provided.

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Part Three

The Learning Process

MANY ANIMALS ARE ALMOST SELF-SUFFICIENT AT BIRTH, being born with response mechanisms which, without training and without help from others, enable them to make an adequate adjustment to their environment. Their complex inborn behavior patterns are called *instincts*. The higher organisms, like monkeys, apes, and men, are helpless at birth. Their only unlearned responses are reflexes and relatively simple co-ordinations. These are inadequate for unaided and untutored adjustment. The human child is most helpless of all. He is dependent upon others for several years and when, at long last, he fends for himself, he is sustained not by instinct but by what he has learned. He is a creature of habit.

The importance of learning in human life becomes clearly apparent when we consider how a person would act if deprived of everything he had learned. Suppose that some drug were discovered which, without injuring your response mechanisms, wiped out all traces of what you had learned. You would retain your physiological maturity, but psychologically you would sink immediately to the level of a baby.

You would have all the normal reflexes and you might even creep or walk. You would have the same physiological needs, like hunger and thirst, that you now possess. But you would not know what to eat or drink nor where to find the means of satisfying your needs. There would be no way of knowing, except possibly through taste and smell, which things were edible and which not. You would wear no clothes and, even if they were given you, you would have no idea, except by observing others, what they were for. If you tried to put them on, you could not button or otherwise fix them. All of the habits of buttoning, zipping and tying that you learned so laboriously in childhood would have disappeared. If food and utensils were placed before you, you could not feed yourself with the latter. You would not even use your fingers, except, possibly, after finding other means inadequate. You would have no attitudes of cleanliness and, if you did, you could not perform the acts required to keep clean. You would have no

knowledge of right and wrong, and no conscience. Your surroundings would be meaningless, your parents and friends but strange creatures somewhat like yourself. You would even seem strange to yourself. If you had anything to communicate to others, which is doubtful, since all ideas are almost certainly learned, you could not communicate. Your vocalizations would be cries and strange sounds, not words. Your gestures would be of no avail because they would be mere reflexes, not the conventionalized motions which people understand. In other things, also, you would lack even the skill and knowledge of an infant. Only after many years of learning could you regain the attitudes, the skills, and the knowledge that you now possess.

Human learning is not limited to direct personal experience. Through language we learn, in the comfort of our homes, our schools and our libraries, what our ancestors learned through actual struggle with their environments. What has been called our "social heritage" represents the fruits of what our ancestors learned concerning themselves and the world about them. One writer has vividly pointed out how dependent we are, even for survival, on what our ancestors learned. He says that if some catastrophe should cause every human being

> . . . to lose all the knowledge and habits which he has acquired from preceding generations (though retaining unchanged all his powers of invention, and memory, and habituation) nine-tenths of the inhabitants of London or New York would be dead in a month, and ninety-nine per cent of the remaining tenth would be dead in six months. They would have no language to express their thoughts, and no thoughts but vague reverie. They could not read notices, or drive motors or horses. They would wander about, led by the inarticulate cries of a few naturally dominant individuals, drowning themselves, as thirst came on, in hundreds at the riverside landing places, looting those shops where the smell of decaying food attracted them, and perhaps in the end stumbling on the expedient of cannibalism. Even in the country districts men could not invent, in time to preserve their lives, methods of growing foods or training animals, or making fire, or so clothing themselves as to endure a northern winter. . . . A few primitive races might live on fruit and small animals in those tropical regions where the human species was originally evolved until they had accumulated a social heritage. After some thousands of generations they would probably possess something which we would recognize as language, and perhaps some art of taming animals and cultivating land.*

Thus we are what we are largely because we can learn, from our own experience and the experience of others, how to adapt to our physical and social surroundings. It is not surprising, therefore, that learning is regarded by many psychologists as the most important psychological process.

* Graham Wallas, *Our Social Heritage.* London: G. Allen and Unwin, 1921, pp. 16–17. The American edition is published by the Yale University Press, New Haven, Conn.

6 THE CONDITIONED RESPONSE

The Conditioning Process • Conditioning Techniques: The experiments on conditioned salivation; conditioned withdrawal; rewarded responses; conditioning of involuntary responses; classical and instrumental conditioning; reinforcement • The Direction of Conditioning • Negative Conditioning • The Relation of Conditioned to Unconditioned Responses • Some Sequences and Time Relations • Age and Conditioning • Generalization and Differentiation: Generalization; differentiation of stimuli • Elimination of Conditioned Responses: Experimental extinction; spontaneous recovery • Higher-Order Conditioning • The Significance of Conditioning in Human Life: Conditioning and acquisition of speech; acquiring attitudes; conditioning and other learning; some practical applications • Summary

Any response is said to be conditioned when some stimulus other than the already effective one comes to arouse or modify it. A newborn child sucks when an object, such as a nipple, is placed in its mouth. Visual stimuli fail to elicit sucking. But, because oral stimulation with a nipple is associated with visual stimulation from the breast or bottle, the child soon sucks in response to this visual stimulation. He now sucks before the nipple reaches his mouth. Likewise, a child receiving his first hypodermic injection attempts to withdraw and becomes emotionally upset as the needle pricks him. Later he attempts to withdraw and becomes emotionally aroused at the sight of the needle, perhaps even at the sight of the doctor. An adult who has been seasick may subsequently feel nauseated even before his boat leaves the wharf. An alcoholic whose liquor has been treated so that it nauseates him later becomes nauseated at the sight, smell, or perhaps even the mention of alcohol.

Examples could be multiplied endlessly. From the time of birth and, as we shall see, possibly earlier, we begin to acquire a vast repertoire of conditioned responses. These include reflexes and emotions elicited by other than their natural stimuli, overt responses and attitudes toward persons and situations, early language responses, and numerous components of simple and complex skills. All owe their existence to the association of originally ineffective stimuli with effective stimuli, and, of course, with the responses aroused by them.

THE CONDITIONING PROCESS

Technically, we refer to the originally effective stimulus as an *unconditioned stimulus.* Thus a nipple in the mouth is an unconditioned stimulus for sucking. Sucking the nipple is referred to as an *unconditioned response.* Many unconditioned stimuli, such as a nipple, food in the mouth, a pin prick, an electric shock, a blow producing the knee jerk, or light causing the pupil of the eye to contract, are what we would call *natural* stimuli for the responses aroused. But some stimuli which have become effective only through conditioning may serve, so to speak, as "unconditioned" stimuli for further conditioning. Thus the sight or smell of food, conditioned to food in the mouth, may serve as stimulation for further conditioning.

Let us return to the sucking example. The

visual bottle, which at first fails to elicit sucking, is referred to as the *conditioned stimulus.* When sucking is elicited by this stimulus, it becomes a *conditioned response.*

Just as any stimulus, once it has become effective in arousing behavior, may be used as an "unconditioned" stimulus for further conditioning, so any response, whether unlearned or learned, may be conditioned so that it is aroused by new stimuli. Our examples have stressed unlearned responses, such as reflexes and emotions, but many acquired responses are conditioned again and again. We learn, for example, that to stop our car we must apply the brake in a certain way. But once we have learned how to apply the brake, many new situations elicit this response, e.g., red lights, stop signs, visual stimulation from another car, and proximity to a sharp curve.

The conditioning process may be illustrated diagrammatically in such a way as to show the S–R relationships. Before the sucking response is conditioned to visual stimulation, we have the following situation:

Unconditioned Stimulus (oral contact) → Unconditioned Response (sucking)
Stimulus to be Conditioned (visual bottle) → Response (looking, but not sucking)

After the stimulus to be conditioned has been paired with the unconditioned stimulus a number of times, and sucking in response to it (now the conditioned stimulus) has developed, the situation is as follows:

Unconditioned Stimulus (oral stimulation) → Unconditioned Response (sucking)
Conditioned Stimulus (visual bottle) → Unconditioned Response (sucking)

The previously neutral or ineffective stimulus, as well as the unconditioned one, now elicits sucking.

CONDITIONING TECHNIQUES

Although conditioned responses had been observed for centuries, it was not until the early years of the present century that scientists saw their theoretical and practical significance. The first to study such responses systematically and to point out their implications for psychology was a Russian physiologist named Ivan Pavlov.

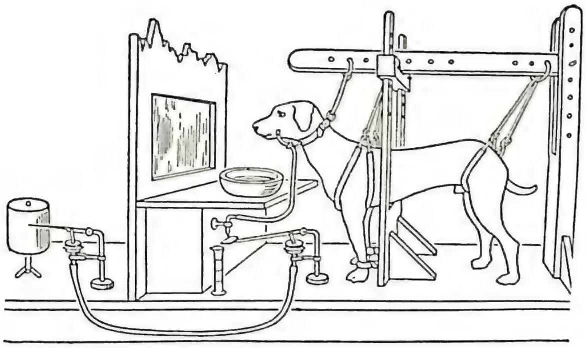
While experimenting on gastric secretion in dogs, Pavlov observed that stimuli frequently associated with the presentation of food arouse salivation, a response originally elicited only by food (or acid) placed in the mouth. This observation led him to experiment with the conditioning process itself.

The experiments on conditioned salivation

Pavlov made an opening in the dog's cheek so that secretions of the salivary gland would run out where they could be measured. He measured the amount of saliva in drops and in volume, as illustrated in Figure 63. In later experiments, the animal was placed in a separate room, so that it would not be disturbed by the recording apparatus and the experimenter. Stimuli were presented by squeezing bulbs or pressing buttons. Observations were made through a window.

Development of a conditioned salivary response to tone is illustrated in Table 2. No drops of saliva were secreted when the tone was first presented. A test with the tone, but no food, after 9 presentations of tone and food elicited 18 drops. A similar test after 15 presentations yielded 30 drops. After 31 presentations, 65 drops were elicited by the sound alone. Ten further presentations, and the test with sound alone yielded 64 drops. A further ten presentations brought a further increase in the number of drops.

Following the general procedure already described, Pavlov and his associates conditioned the salivary response of dogs to a wide variety of stimuli — visual, auditory, olfactory, and cutaneous. Pavlov pointed out that in each case a "new nerve path"



63 **Collection of Saliva in Pavlov's Early Experiments**

Observe that the drops of saliva, as they fall upon the platform above the calibrated glass tube, activate a recording mechanism which makes a scratch for each drop on a moving smoked drum. (From Yerkes, R. M., and S. Morgulis, "The Method of Pavlov in Animal Psychology." Psychological Bulletin, *1909, vol. 6, p. 257.)*

had somehow been opened up between eye, ear, nose, or skin, and the salivary mechanisms. These paths were assumed by him to involve the cerebral cortex; hence, he referred to his work as "investigation of the physiological activity of the cerebral cortex." We now know that, while conditioning of an intact animal involves the cerebral cortex, conditioning also occurs in animals deprived of their cortex.[1] Some investigators [2] appear to have conditioned dogs with only the spinal cord remaining but there is controversy as to whether this is true conditioning.[3]

Pavlov did not stop when he had shown that a wide variety of previously ineffective stimuli may, by association with food, come to elicit the salivary response. He described many phenomena which show that, normally, conditioning is far more complex than at first appeared. Some of these phenomena are considered in this chapter. Pavlov also related many of his observations to aspects of everyday human life, especially habit formation, sleep, and development of neurotic behavior. He believed that all learning is ultimately reducible to conditioning of reflexes. To use his own words, "different kinds of habits based on training, education, and discipline of any sort are nothing but a long chain of conditioned reflexes." [4]

Pavlov's procedures were soon modified to fit them for use with human subjects, both child and adult. A suction cup placed in the mouth over the salivary gland allowed investigators to collect saliva without the operation required when dogs are used. Some experimenters later did away with the suction cup, using standard cotton pads instead. A cotton pad was placed in the cheek before presentation of the stimulus and weighed after presentation. Its increased weight provided a measure of the amount of saliva secreted. The research on conditioned salivary responses in children, and to some extent in adults, has verified the phenomena observed by Pavlov in dogs.[5]

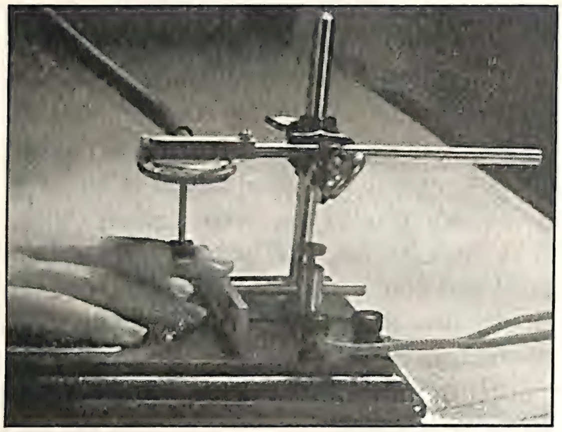
TABLE 2. DEVELOPMENT OF A CONDITIONED SALIVARY RESPONSE TO A TONE OF 637.5 VIBRATIONS PER SECOND

(Anrep: *J. Physiol.*, 1920)

Number of presentations of sound and feeding	*Number of drops of saliva in 30 seconds*
1	0
9	18
15	30
31	65
41	64
51	69

Conditioned withdrawal

Vladimir Bechterev, another Russian physiologist, experimented with the so-called "protective reflex." This is withdrawal of some part of the body in response to painful stimulation, such as an electric shock. Bechterev used dogs and human subjects. A dog was strapped in a harness and electrodes were applied so as to shock a paw. Withdrawal of the paw, first evoked by shock alone, could be conditioned so that it was



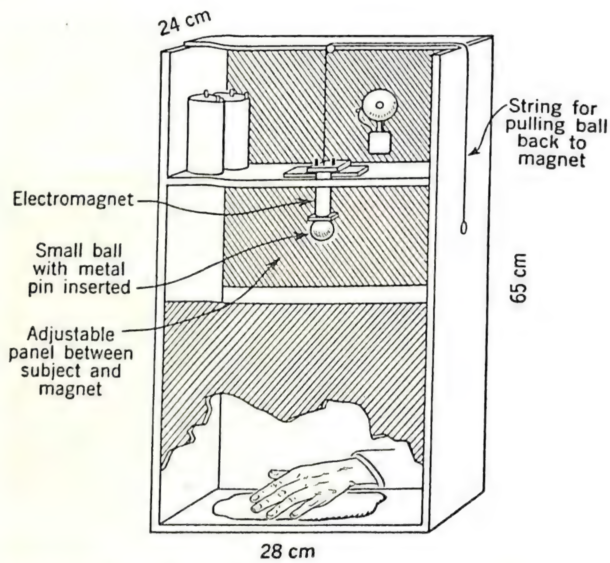
64 **Conditioning Finger Withdrawal**

The unconditioned stimulus is a shock to the finger, and the unconditioned response is lifting the finger. As the finger is lifted, pressure is exerted on a small tambour, thus causing a writing lever to move upward and record the response on a moving smoked drum. If a bell, say, is rung just before the shock is given, and the bell-shock sequence is repeated sufficiently often, the subject eventually lifts his finger when the bell rings and before he receives a shock.

elicited by a wide variety of stimuli. This method, as applied to human subjects, involved withdrawal of the foot, hand, or finger from an electric shock. Finger withdrawal, as illustrated in Figure 64, has been widely utilized in laboratory experiments designed to investigate the facts and principles of conditioning.

In experiments on withdrawal, the situation may be arranged so that the shock is received regardless of the subject's reaction, or it may be arranged so that a sufficiently rapid withdrawal, in response to the conditioned stimulus, brings escape from shock. Conditioning occurs whichever procedure is used, but its development varies somewhat depending upon the procedure.

Conditioned withdrawal without the use of shock may be demonstrated by using the apparatus shown in Figure 65. A golf ball with a metal pin inserted is held against the magnet. When the circuit with the magnet is broken, the ball falls toward the subject's hand and, if the hand is withdrawn too slowly, hits it. The panel prevents the subject from seeing the ball on the magnet. When the ball is released, however, it comes into view soon enough so that there is time to withdraw the hand and avoid being struck. Hand withdrawal is the unconditioned response. The sight of the falling ball is the "unconditioned stimulus." As a conditioned stimulus, a bell, a flash of light, or some other form of stimulation is used. A bell, for example, may be rung as the ball leaves the magnet, thus preceding the seen ball by a fraction of a second. As conditioning occurs, the hand starts to withdraw before the ball is seen. Eventually, ringing the bell alone produces a reflex withdrawal, even though no ball is dropped.



65 **Conditioning Hand Withdrawal**

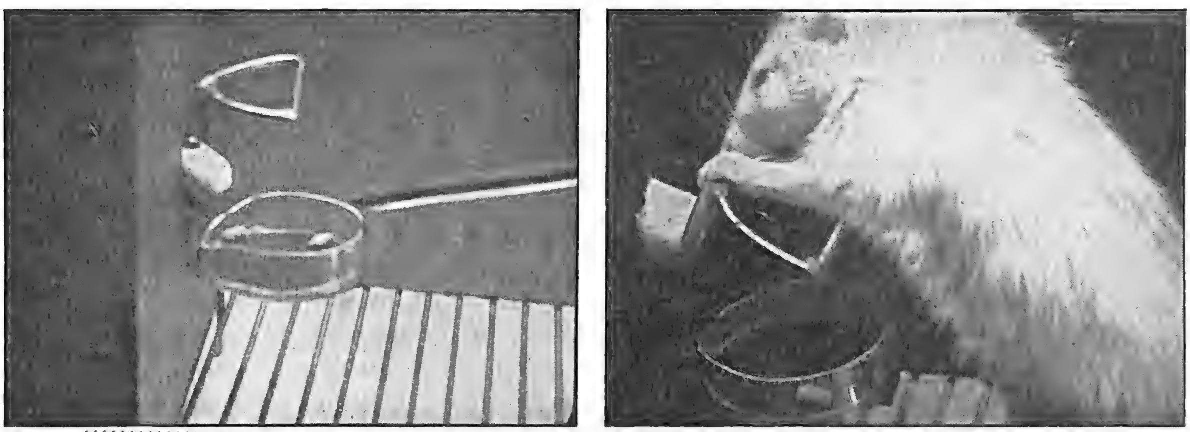
This apparatus was designed by using the descriptions given in Bousfield, W. A., "A Simple Demonstration of the Conditioned Response," Science, *1939, 90, p. 70; and Foley, J. P., "A Classroom Demonstration of the Conditioned Response."* Am. J. Psychol., *1941, 54, 418–422.*

Rewarded responses

All conditioning probably involves a reward of some kind, although, in the conditioning of involuntary responses, the problem of reward becomes more complicated. Food given to a hungry dog that salivates in response to a bell may be considered a reward for such anticipatory salivation. Conditioned withdrawal of a dog's foot, even when it does not bring escape from shock, may constitute a relief from anticipatory tension, hence a reward for responding. A much more obvious reward is involved in situations, like those illustrated in Figures 64 and 65, where withdrawal brings cessation not only from anticipatory tension but also from actual punishment.

In certain conditioning experiments, now to be described, the organism's response brings an obvious and direct reward. Thus, in a Russian experiment, children were conditioned to squeeze a bulb in response to a signal. This response produced a piece of chocolate. At first the bulb was squeezed voluntarily, as a piece of chocolate was seen sliding down the tube, but it could not be squeezed in time to release the chocolate. However, a bell was rung as the chocolate was released, but before it became visible to the subject. The mechanism was timed so that, if the child squeezed in response to the bell, the chocolate fell within reach. The children learned this bell-squeeze association in from two to eighty-eight trials.[6]

Another, somewhat similar reward technique, has been used widely in experiments with rats. The rat is placed in a box (Figure 66) which contains a lever and a small food cup. During its explorations, the animal eventually depresses the lever, thus releasing a pellet of food. More or less gradually the rat associates food and lever pressing, so that it keeps pressing the lever and eating the pellets, until satiated. The situation is sometimes arranged so that the only lever pressing which releases food is that following a signal, such as a bell. Then the animal learns to press when the signal is given and not at other times.[7]



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Conditioning a Rewarded Response

This is the response end of a modified form of the Skinner Conditioning Box, designed by Professor B. F. Skinner of Harvard University. Pressing the stirrup-shaped lever releases a small pellet of food which falls into the tray below. The illustrations are from the film "Motivation and Reward in Learning," by Neal E. Miller and Gardner Hart, distributed by the Psychological Cinema Register, Pennsylvania State College, Pa. (Courtesy of Neal E. Miller.)

In one investigation like the above, children between the ages of two and five years learned to obtain a small piece of candy by depressing a lever placed in their playroom. The results were quite similar to those obtained with rats. After accidentally pressing the lever, a child would continue to press, and at a faster and faster rate. In one instance the rate reached twenty responses per minute.[8]

Conditioning of involuntary responses

In the experiments on finger-lifting, hand withdrawal, bulb squeezing, and lever pressing, human subjects may oblige the experimenter by voluntarily responding to the "conditioned stimulus." This is also true of experiments in which the eye blink to a puff of air[9] and the knee jerk to a blow on the patellar tendon[10] are conditioned so that they are elicited by auditory stimuli.* But responses over which the individual has no control are also conditioned. One of these is the pupillary response. The subject cannot contract or dilate his pupil to please the experimenter.

When a bell is rung, the pupil dilates, as it also does when illumination is lowered. Increasing illumination causes the pupil to contract. If, now, a bell is rung, and this is followed by an increase in illumination, the pupil dilates in response to the bell and contracts in response to the increased illumination. Upon repeated stimulation with the bell, followed by the increased illumination, however, the pupil eventually reacts to the bell as it does to the light — in other words, it contracts. Likewise, the pupil may be conditioned to dilate in response to a bell more than it dilated before conditioning.[11] The pupillary response has also been conditioned to stimulation provided by the gripping of a dynamometer in the hand; to the subjects' repeating the words "contract" or "dilate," and even to the thought "contract" or "dilate."[12] Psychologists have conditioned numerous other human involuntary responses, including salivation, sweat-gland secretion, skin temperature, and the flattening of the alpha electroencephalogram which normally appears (see p. 62) when the eyes are opened.[13]

That conditioning is not necessarily voluntary is also demonstrated by experiments in which the subject is feebleminded, hypnotized, or absorbed in some other activity. In each of these instances, he is conditioned without any knowledge of what is taking place. In one such experiment, normal subjects learned a maze and, at times, sucked lollypops while red or green lights flashed on. Subjects did not know that their salivary responses were being conditioned, but thought the problem to be one of maze learning. Actually, their salivary responses were conditioned more readily than in the subjects who, instead of being distracted, knew what was going on.[14]

Classical and instrumental conditioning

Procedures involving the same sequence of stimuli, regardless of what the organism does, are frequently referred to as *classical,* since they were the earliest procedures used. In Pavlov's experiments, for example, the dog received food whether or not it salivated in response to the conditioned stimulus. In Bechterev's experiments, electrodes were strapped to the limb so that a shock was received even though conditioned withdrawal occurred.

Procedures which allow the organism to escape shock by responding to the conditioned stimulus or to receive a reward by squeezing a bulb or pressing a lever are examples of what has been called *instrumental* conditioning. This conditioning is called instrumental because the organism's re-

* Voluntary responses have a longer latency (lag between stimulus and response) than is found for reflex responses. Thus latency may be used to determine whether a response is reflex or voluntary.

sponse to the conditioned stimulus is instrumental in its escape from shock, or in its obtaining a reward.[15]

Several experiments have compared the classical and instrumental use of shock. The results are not completely consistent from one study to another, but animals conditioned so that they can escape a shock by responding to the conditioned stimulus usually condition more readily than animals which receive the shock regardless of their response.[16]

Reinforcement

The rewarding element in conditioning experiments is said to reinforce the response by reducing, for example, the tension produced by hunger and pain. Reinforcement is most obviously involved in so-called instrumental conditioning, where the animal learns that his response brings food or cessation of punishment. It is not so obviously present in classical conditioning, including the conditioning of involuntary responses. Even in these instances, however, the fact that one stimulus always follows another (e.g., conditioned-unconditioned) may build up tensions or "expectations" which are reduced after the second stimulus appears. Still greater tension-reduction perhaps occurs when the conditioned response intervenes.

Reinforcement is an important concept in theories of learning, hence it receives further consideration in Chapter 8.

THE DIRECTION OF CONDITIONING

When the conditioned stimulus is first applied, the subject may make some response to it, and may continue to make that response, even after conditioning has occurred. Thus, a bell may cause an animal to prick up its ears, although it does not cause it to salivate. Why, then, does not the ear-pricking response become conditioned so that food arouses it? Why, in other words, does the conditioning go from bell to salivation instead of from food to ear-pricking?

The answer is that conditioning is in the direction of the more relevant response or, perhaps we should say, the prepotent response. Salivation of a hungry animal in response to food is a vital activity. It is relevant to the metabolic processes of the animal. Pricking up the ears, however, is of no such biological significance. Thus, the salivary response dominates. Withdrawal of the foot from an electric shock, contraction of the pupil in response to changes in illumination, blinking of the eye in response to a puff of air, and grasping in response to food which grasping makes accessible, are all biologically significant responses, since they either prevent injury or provide a reward.

NEGATIVE CONDITIONING

Negative conditioning, or negative adaptation, is a common occurrence in everyday life. It is learning not to make a response. If a sexually mature male rat is shocked every time it approaches a female, it soon avoids females. If cockroaches are given an electric shock when they run into the dark, they soon make for light instead of darkness. Alcoholics develop an antipathy for alcohol as a result of drinking alcohol containing a drug which produces violent vomiting. A child who avoids the fire after being burned, who refrains from putting his finger into electric light sockets after once being shocked, or who gives up thumb-sucking after he has had several experiences of sucking nasty-tasting thumbs, provides further illustration of negative conditioning.

THE RELATION OF CONDITIONED TO UNCONDITIONED RESPONSES

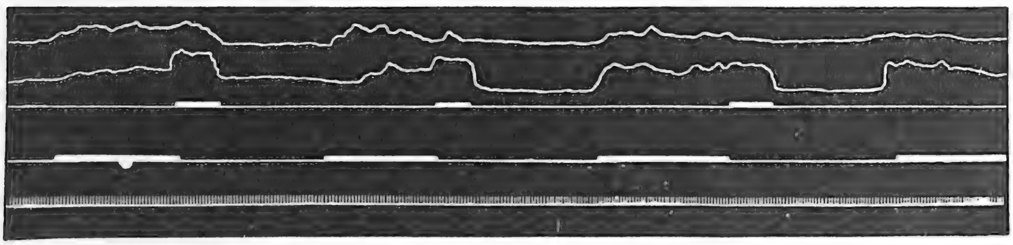
Upon superficial observation, it appears that conditioning is merely the arousing of an old response by a new stimulus. This,

however, is not always true. In Pavlov's investigations, salivation was elicited by a stimulus which previously failed to arouse it. Thus, salivation (the old response) previously elicited only by food or acid was now elicited by a previously neutral (new) stimulus like light, sound, or touch. But salivation is an exception to the rule. It has been shown in the case of withdrawal, and many other responses, that the reaction, once it has been conditioned, is in some respects a new one. The response to an electric shock applied at the foot, for example, is diffuse. A dog stimulated in this way barks, struggles, and lifts feet not directly stimulated. Eventually, however, the conditioned dog lifts the foot stimulated, and that is all. Likewise, the baby who moves all limbs when one is first stimulated electrically comes to move only the latter limb. This is partially illustrated in Figure 67. Behavior that is generalized thus becomes specific.

When the conditioned stimulus always precedes the unconditioned stimulus, conditioned responses are usually anticipatory. That is to say, the organism makes a response to the conditioned stimulus which suggests a getting ready for the unconditioned stimulus. The subject may become tense, it may assume an expectant attitude, or it may exhibit an abbreviation of the response made to the unconditioned stimulus. Thus, if respiration is being conditioned, onset of the conditioned stimulus (tone) may produce a slight change in respiration, which is followed, when the unconditioned stimulus (shock) is presented, by a large change in respiration.

SOME SEQUENCES AND TIME RELATIONS

In all of the examples of conditioning so far mentioned, the conditioned stimulus has preceded the onset of the unconditioned stimulus or has been presented at the same time as this stimulus. Pavlov believed, on the basis of certain experiments performed



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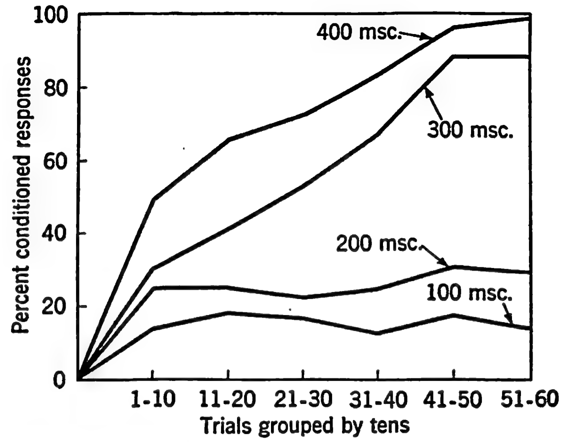
Changes in Withdrawal in Conditioning of an Infant

The infant whose conditioning is represented here was twenty-one months old. When an electric shock (middle line) was applied at one hand, the arm was withdrawn, as shown in the line above. The other arm and the legs were also active. Withdrawal of one foot is represented by the top line. At first, the conditioned stimulus (sound of a metronome) produced no withdrawal responses. Gradually the metronome elicited activities similar to those aroused by shock. In this record, which represents the end of the conditioning process, one can observe that both the arm and leg are being withdrawn in response to the metronome, before the hand is actually shocked. What is of especial interest is the fact that, as conditioning proceeds, the response of the arm to the metronome alone becomes more pronounced while the response of the leg diminishes. At the last stimulation shown, the arm alone is appreciably withdrawn. (After Marinesco, G., and A. Kreindler, "Des Réflexes Conditionnels: 1. L'organisation des réflexes conditionnels chez l'enfant." J. de Psychol., *1933, 30, p. 873.)*

in his laboratory, that the conditioned and unconditioned stimuli must either be presented simultaneously or the conditioned presented shortly before the unconditioned stimulus. Later research has indicated, however, that conditioning sometimes occurs when the conditioned stimulus follows the unconditioned. This is called *backward conditioning*.

The relative effectiveness of different sequences and time intervals has been investigated extensively, both in men and animals. There is no doubt that the most effective sequence is one where the conditioned stimulus precedes the unconditioned stimulus — where, for example, the bell precedes the food. The most effective time interval for this sequence seems to be around .5 second.[17] In one study involving finger withdrawal, intervals both shorter and longer than this produced fewer conditioned responses.[18] The data illustrated in Figure 68 are from a study in which the eyelid response to a puff of air was conditioned to a flash of light. Different groups of students were conditioned with the conditioned stimulus (light) preceding the unconditioned stimulus (air puff) by intervals of 100, 200, 225, 250, 300, and 400 thousandths of a second. Only the results for the first two and the last two groups are shown. One will observe that, the longer the interval between the light and the air puff, the more rapid the acquisition of the eye wink to light.[19] In view of other research, one would be safe in concluding that, had the interval been much longer than .5 second, acquisition of the response would have been retarded.



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Acquisition of a Conditioned Eye Blink as a Function of the Interval by Which the Conditioned Stimulus Preceded the Unconditioned Stimulus

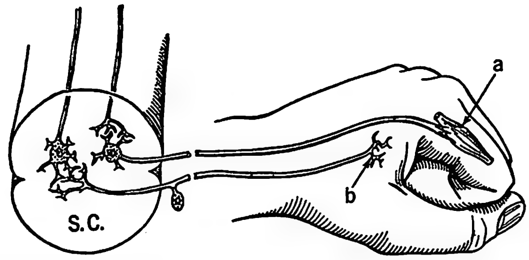
The conditioned stimulus was a flash of light. This preceded the unconditioned stimulus (a puff of air) by from 100 to 400 milliseconds (msc.) *as indicated at the right. At the left is shown the percentage of conditioned responses. (After Kimble, G. A., "Conditioning as a Function of the Time Between Conditioned and Unconditioned Stimuli."* J. Exper. Psychol., *1947, 37, p. 8.)*

AGE AND CONDITIONING

Two problems are of especial interest here: (1) At what age does conditioning begin? (2) Does susceptibility to conditioning vary with age?

Nobody knows how soon conditioning begins. For all we know, it may begin early in the fetal period. Some have claimed that the grasping reflex, developed by the fifth fetal month, is a conditioned response. They point out (see Figure 69) that, whenever the fetus happens to close its hand, it stimulates receptors in the palm. After finger movement and palm stimulation have occurred together a number of times, palm stimulation alone, as when an object is placed against the palm, could elicit the grasping response. It is conceivable that some fetal responses are acquired in this way.[20]

Fetuses in the seventh and eighth months have been conditioned to loud noises *in utero*. A loud clapper sounded near the mother's abdomen elicited a "startle" response of the fetus. This response was not aroused, initially, by stimulation of the maternal abdomen with a small vibrator. In some fetuses there was a "startle" response



69

Theoretical Origin of the Grasping Reflex

Impulses travel into the muscle a *causing it to contract. If, during this contraction, skin receptors at* b *are stimulated, by the finger tips, impulses pass over the afferent fiber to the spinal cord S.C. Should the response of* a *be frequently followed by stimulation of* b, *central connections may be made so that stimulation of* b, *which at first failed to arouse grasping, now elicits this response. (Modified from Shaffer, L. F.,* The Psychology of Adjustment. *Boston: Houghton Mifflin, 1936, p. 39.)*

to the vibrator alone after as few as fifteen paired presentations of the vibration followed by the noise. One fetus still responded to the vibration alone after an interval of eighteen days, thus showing that the conditioned response, once acquired, could be retained. Control experiments demonstrated that the responses were fetal rather than maternal and that they did not develop unless paired vibration-noise stimulations were applied. The latter point is important because, in an experiment covering days or weeks, especially in early life, some responses not present earlier may mature, hence only appear to result from conditioning.[21]

There have been several studies of conditioning during the first few weeks of life. Babies have been conditioned to suck, blink, withdraw the foot, and to change their respiration.[22] As the school age is approached, susceptibility to conditioning becomes more pronounced. In one study, where swallowing responses (originally elicited by chocolate) were conditioned, the required number of paired combinations of conditioned and unconditioned stimuli averaged 8 at one year, 7 at two years, 5 at three years, and 4 at four and five years.[23]

Beyond the preschool age, conditioning of voluntary reactions becomes somewhat more difficult to accomplish, especially in laboratory situations.[24] The subject wonders what is going on. He may try to produce the results which he thinks the experimenter desires. He may be resistant, trying not to do what he thinks is expected of him. Or he may change his attitude during the experiment, thus bringing unpredictable results. For example, a girl being conditioned to finger withdrawal began to lift her finger when the buzzer sounded. Then, all of a sudden, she began to keep her finger down until shocked. When asked to explain this change she said, "My finger was jumping up as soon as the buzzer went on. I realized that it shouldn't be doing that, so I held it down." Thus her change of attitude spoiled what might otherwise have been a good demonstration of conditioning.

For these reasons, older children and adults are most readily conditioned when they are distracted, and thus do not know what is going on, or when we condition responses over which they have little or no voluntary control.

GENERALIZATION AND DIFFERENTIATION

Generalization

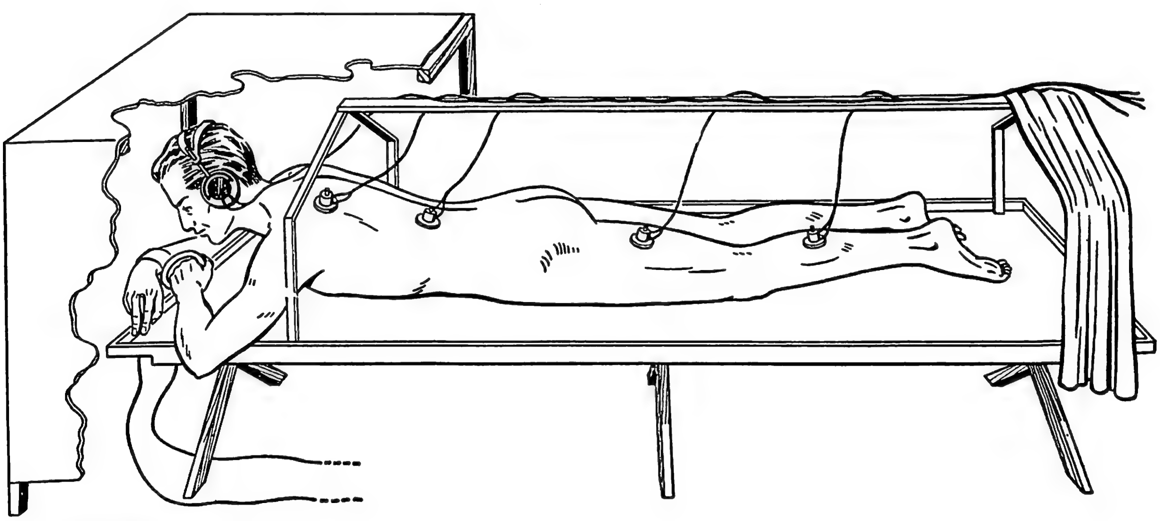
If a dog is conditioned to salivate in response to a tone, it will very likely make the same responses to tones differing from the one involved in conditioning. It may even make the response to bells, buzzers, and other sounds. If a child is conditioned so that it makes a fear response to a white rat (Chapter 14), it may be afraid, also, of a white fur coat, a white rabbit, and a mass of absorbent cotton. These are examples of

stimulus generalization. Conditioning occurs to a certain class of stimuli rather than to a specific stimulus. Any one of this class may elicit the response.

The same phenomenon is demonstrated by stimulating different parts of the skin after vibration at one point has been conditioned as illustrated in Figure 70. The unconditioned stimulus was a shock to the right hand, and the unconditioned response, a change in electrical resistance of the skin (due to perspiration). This change in electrical resistance is known as a *psychogalvanic response,* or a *galvanic skin reflex* (see pp. 348–349).

When conditioning to vibration on the shoulder had been obtained, so that changes in electrical resistance previously associated with shock were now made to tactile vibration alone, the other points indicated in Figure 70 were stimulated. Vibration on the middle of the back yielded a galvanic reaction, but smaller than that on the shoulder. Stimulation of the thigh likewise elicited a galvanic response, but one smaller than that on the middle of the back. A still smaller galvanic reaction was elicited by stimulation of the calf. Conditioning of other points than the shoulder region also demonstrated generalization. These results verify for man the comparable results found by other investigators, including Pavlov, for dogs and sheep.

Pavlov attributed this generalizing tendency to a spread of effects from the region stimulated to other parts of the organism,



70

Arrangement for Conditioning the Galvanic Skin Reflex to Vibration of the Skin

The subject lay in a box-like compartment which separated him from the rest of the environment. Headphones in which there was a constant buzz prevented him from hearing outside noises. The unconditioned stimulus (an electric shock) was administered to the right hand. The unconditioned response was sweating of the left hand, indicated by changes in electrical resistance of the skin (galvanic skin reflex). Changes in electrical resistance were recorded by using electrodes and a sensitive galvanometer. Vibration of the skin at one of the spots where the electrically activated vibrators appear was the conditioned stimulus. The conditioning sequence was vibration of the skin followed by shock. (After Bass, M. J., and C. L. Hull, "The Irradiation of a Tactile Conditioned Reflex in Man." Journal of Comparative Psychology, *1934, vol. 14.)*

especially to other parts of the brain than those primarily excited. He referred to the phenomenon as *irradiation of excitation.*

Differentiation of stimuli

Although conditioning is usually to a class of stimuli rather than to a specific stimulus, specificity is obtainable if the appropriate procedures are used. If you wish to condition to a tone of 256 cycles and not to a tone of 500 cycles, you reinforce only one of them. You present both tones, but each in a varied sequence. The unconditioned stimulus follows only one tone, that for which specificity of response is desired. Suppose that the tone selected for conditioning is 256 cycles, and that the unconditioned stimulus is food. Then you will present food every time that a tone of 256 cycles is sounded, but never when the other tone is used. Eventually, if the two tones can be differentiated, the animal salivates in response to 256 cycles and not in response to 500 cycles.

Stimulation of any point on the skin, as in Figure 70, may likewise be made non-effective, if it is presented frequently but never followed by electric shock, or whatever the unconditioned stimulus happens to be. In other words, the organism comes to discriminate between reinforced and non-reinforced stimulation.

Differential conditioned reflexes provide us with an important tool for analysis of sensory stimulation. Animals and infants cannot tell us what they sense, but their differential conditioned reactions tell the story just as well as words could tell it. If we wish to know how small a difference in loudness a dog can discriminate, for example, we condition its withdrawal response to a certain intensity of stimulation and not to another widely different intensity. The latter is presented frequently, but not reinforced. After the animal withdraws its foot for one sound and not for another, we gradually reduce the difference in loudness. The smallest difference to which it responds is thus determined.

Sometimes, as the difference in reinforced and unreinforced stimulation becomes too small for the animal to discriminate, a "nervous breakdown" occurs. Another chapter deals with such "neurotic" behavior.

ELIMINATION OF CONDITIONED RESPONSES

Conditioned responses are sometimes fragile, disappearing within a few weeks after formation. On the other hand, some conditioned reactions, even when studied under relatively artificial laboratory conditions, last for years. Many of those developed in everyday life last as long as we live.

Experimental extinction

Once a conditioned response has been formed, how may it be eliminated? The method most widely used is to present the conditioned stimulus repeatedly without reinforcing it — without following it with the unconditioned stimulus. Thus, if the bell that has been eliciting a salivary response is rung without presentation of food, the amount of saliva decreases gradually. Finally, there is no salivation in response to the conditioned stimulus. The shoulder region of the subject in Figure 70 was conditioned so that it yielded a galvanic skin reflex. Vibration of this region was then repeated, without presentation of shock. There was a gradual weakening of response and, finally, complete elimination.

Spontaneous recovery

An experimentally extinguished response usually returns later. Pavlov called this phenomenon *spontaneous recovery.* If the response is continually extinguished, it grows progressively weaker at each spontaneous recovery. Finally, it fails to return.

HIGHER–ORDER CONDITIONING

Pavlov found that, once conditioning was well established, he could use the conditioned stimulus as the "unconditioned" stimulus for further conditioning. In other words, if the animal had been conditioned to salivate in response to a bell, Pavlov could now use the bell instead of food to obtain further conditioning. The situation is as follows:

Original conditioning

Food → Salivation
Bell → ?

Bell → Salivation

Second-order conditioning

Bell → Salivation
Light → ?

Light → Salivation

Pavlov failed to obtain higher than second-order conditioning in dogs, but he believed that there is no discoverable limit to the orders of conditioned responses which man acquires under conditions of everyday life.

Development of a second-order conditioned response is difficult in the laboratory, because of the occurrence of experimental extinction. The bell, for example, must be reinforced frequently with food so that salivation to it does not extinguish while it is being used as the "unconditioned" stimulus.

THE SIGNIFICANCE OF CONDITIONING IN HUMAN LIFE

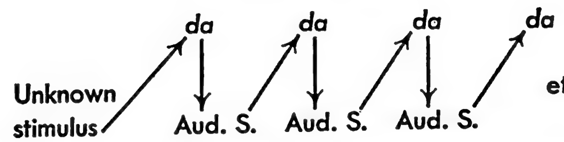
Conditioning and acquisition of speech

Speech, at least in its early stages, provides many examples of conditioning. Every time the baby makes a sound, such as *da*, he hears himself say it. Thus, whatever stimuli make him exhibit the response in the first place are always associated with his hearing *da*. This is all that we need for development of a conditioned response. Very soon a conditioned reflex circle is established. This may be diagrammed as follows:

Initial situation

Unknown stimuli → *da*
Auditory stimulus → ?

After conditioning



In other words, the baby says *da* and hears himself say "da." The latter, having become a conditioned stimulus for the vocalization *da*, leads the child to say "da" again. So he babbles *da-da-da* . . . until fatigue sets in or some other stimulus gets the right of way.

Once a child copies his own response in this way, the next step is to copy — or attempt to copy as far as he is able — the response of someone else. If someone else says "da," the child repeats it. But if the person says "door," the child, because of the similarity of this sound to "da," says "da." Later, he learns by other means to say "door."

Getting the meaning of words — relating them appropriately to objects and situations — can also be accounted for in terms of the conditioning process. The child says "ma-ma," for example, and the mother appears. This happens a few times, and the mother (or anyone even remotely resembling her) is represented by the vocalization "ma-ma." The situation may be diagrammed as follows:

Before conditioning

Unknown stimuli → *ma-ma*
Visual stimulus (mother) → ?

Visual stimulus (mother) → *ma-ma*

Children also learn, through the conditioning process, the relation between sounds made by others and the objects, situations, and acts associated with these sounds. For example, they hear the word "doll" said while a doll is simultaneously present, and thereby learn to associate the object and the sound that represents it.

Acquiring attitudes

Many of our attitudes — our tendencies to respond positively or negatively to objects, situations, persons, or ideas — are acquired early in life through the conditioning process. We put our hand on the hot stove and thereafter have a negative attitude toward hot objects. Our parents fondle us, give us toys, and allow us to engage in such pleasurable activities as sucking lollypops and eating ice cream. Consequently, we develop positive attitudes toward them. We like them and seek rather than avoid their presence.

Conditioning and other learning

Pavlov, as we have seen, believed that all learning is reducible to conditioned responses. Habits, for him, were chains of conditioned reflexes, arousal of one reflex serving as the stimulus for arousal of the next.

This view has been the starting point for various theories of learning, one of which is considered in Chapter 9. We may say at this point that whether or not conditioning should turn out to be the keystone of all learning, it is certainly an important process for the acquisition of many early skills and attitudes.

Some practical applications

Psychiatrists find conditioned-reflex principles helpful in the interpretation of abnormalities, like morbid fears, aversions to food, compulsions to steal, and other neurotic behavior. Pavlov himself wrote a book entitled *Conditioned Reflexes and Psychiatry*.[25] Much of the work on experimentally produced neuroses (Chapter 13) has been stimulated by research on conditioned responses.

Conditioning is often a practical technique for the elimination of undesirable behavior. Let us take *enuresis* (bed-wetting) for example.[26] The child who wets the bed beyond the age when children normally have control over urination does so because, while he is asleep, the stimuli provided by bladder tensions are not sufficiently strong to wake him before bed-wetting occurs. Putting it another way, he is not sufficiently sensitive to the signals coming from his bladder. He has not been conditioned to respond to these stimuli. But they can be made effective by conditioning. The child is required to sleep on a mat with fine wires inside. Wetting the mat short-circuits the wires. This short-circuiting rings a bell. The child is instructed to get up and go to the bathroom whenever the bell rings, whether or not he needs to urinate further. Before going to the bathroom, he breaks the circuit by opening a switch. After several nights, the bladder tensions wake the child before the bell rings. Weak as his bladder tensions are, waking and getting up have been conditioned to them.

Another practical application of conditioned-response procedures utilizes the experimental-extinction principle. Persons who are afraid of enclosed places, elevators, cats, and so on, normally avoid the feared situations, and experimental extinction cannot occur. These people are sometimes cured by repeatedly forcing the feared situations upon them.[27] Thus, a man who had avoided elevators for years was cured by forcing him to ride up and down in an elevator. This method must be used with great care, however, for some individuals become even more fearful as a result of such treatment.

A psychologist has cured individuals of nail-biting and other undesirable habits by a process resembling extinction.[28] He made

them bite their nails on schedule. Since they had to bite their nails many times when the usual tension or nervousness was absent, there developed what amounts to a dissociation of tension and nail-biting.

Another practical application of conditioned-response technique is that of discovering the existence of sensory capacities in babies, the feebleminded, and the insane. Here, for example, is a child believed to be deaf. For some unknown reason, it makes no response to sounds of any kind. When its foot is pricked, however, the limb is withdrawn. A bell is presented several times just in advance of the prick. If, now, the baby comes to withdraw its foot at the sound of the bell, we know that, whatever the cause of its lack of normal response to sounds, its auditory mechanisms are functioning.[29] Conditioned-response techniques have also been used to discover how well babies differentiate stimuli.

SUMMARY

A response is said to be conditioned when some previously non-effective stimulus arouses it. Thus, the bell, through being presented with salivation, comes to elicit it.

All conditioned-response techniques call for association of an effective (unconditioned) stimulus and a non-effective (conditioned) stimulus. They differ, however, according to the nature of the response conditioned (salivation, withdrawal, and so on) and according to the presence or absence of an escape or reward element (classical or instrumental conditioning).

The most effective sequence is one in which the conditioned stimulus (for example, bell) precedes the unconditioned stimulus (for example, food). The most effective time interval between the two stimuli is a fraction of a second.

The response which has the greatest biological significance, which is most consonant with the organism's needs, is the one conditioned, thus the dog salivates for a bell rather than pricking up his ears for food.

The conditioned response is not always the previous unconditioned response, now being elicited by a previously neutral stimulus, for some conditioned activities are merely anticipatory, and others become much more specific than they were before conditioning occurred. Thus, the baby who withdrew its hands and legs when shocked on a hand came finally to withdraw only the appropriate hand.

The conditioned response is often aroused by many stimuli other than the stimulus used in conditioning. This is stimulus generalization, believed by Pavlov to depend on irradiation of excitatory processes. Specificity is obtained by presenting various stimuli, but reinforcing only one of them. Thus, a bell is always followed by food, but a buzzer, tone, and so on, is never followed by food. The subject then salivates to a bell, but not to the other stimuli. We say that a conditioned differentiation or discrimination has developed.

Conditioned responses are eliminated by a process known as *experimental extinction*. The procedure used in experimental extinction is repeatedly to present the conditioned stimulus without reinforcement. Under these conditions, the response gradually disappears. It may, however, recover after a time. This is known as *spontaneous recovery*.

Once a stimulus has come to arouse a response, it may be used in association with other stimuli in such a way as to make them, also, arouse the response. This is higher-order conditioning. To illustrate this process, a bell that produces salivation is paired with light (which does not elicit salivation). Eventually, the light also arouses the response. According to Pavlov, there is theo-

retically no limit to the orders of conditioned responses which human beings may acquire in this way.

Conditioning can begin quite early—even in the late fetal stage. The ease with which a child's voluntary responses may be conditioned increases up to the age of four or five years, then decreases with increasing age. One reason for this is that the older individual develops attitudes which interfere with naive response. With older children and adults, the most dependable results are obtained when the subject's attention is turned elsewhere or when responses over which he has little or no control are being conditioned.

Conditioning is the basis of many early behavioral acquisitions, including early language responses, but whether it is the basis of all learning is still a controversial question which we shall consider in Chapter 9. Conditioning procedures have had several interesting applications in psychiatry and child training.

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7 ACQUIRING SKILL

Information and Skill • Learning in Animals: Learning to discriminate; maze learning; the problem box; learning by imitating; the detour problem; use of tools • Human Learning: Human maze learning; problem boxes; the detour problem; learning by imitation • Complex Motor Skills • Verbal Skills: Learning to speak; memory experiments; substitution learning • Levels of Complexity in Habit Formation • Learning Curves: The physiological limit; plateaus • Transfer: Bilateral transfer • Transfer from One Activity to a Similar Activity: Transfer from one type of activity to a different type; transfer in verbal learning; bases of transfer; similarity of contents; formal discipline; habit interference • Summary

Learning to salivate in response to a bell, to withdraw a limb at a signal, to develop positive or negative attitudes toward a previously neutral situation, or to repeat *Da* when one hears himself or someone else say it, are relatively simple habits — too simple to be called skills. In addition, their appearance is earlier than that of most skills.

Skill as such is proficiency in the performance of some task. The task may be speaking, typing, playing a musical instrument, driving a car, flying a plane, sending and receiving coded messages, reciting a poem, playing bridge, or using the procedures of some art or science.

One major classification of skills separates the motor and the verbal. The activities involved in *motor skills* are predominantly overt. *Verbal skills* are those in which language activities predominate. One of the purest examples of such a skill is reciting a poem or a lesson. Although we call such skills "verbal" they obviously involve motor activities. One speaks with his vocal musculature and, as we shall see in the chapter on thinking, even, to some extent, thinks with it. Motor skills may also involve implicit verbal activities, as, for example, when one tells himself what to do while learning a motor skill, the performance of which has been described to him vocally or in writing. Motor skills in their purest form are of course found in organisms below man, for these do not verbalize.

INFORMATION AND SKILL

Whether it occurs in animals or men, however, acquisition of skills implies more than an overt motor or verbal performance. Underlying overt performance is the process of discriminating or perceiving — the process of differentiating aspects of the environment and learning, as one psychologist put it, "what leads to what." During the course of observing and otherwise responding to its environment, an organism may thus acquire much potentially useful information. Whether or not this information results in skilled performance may depend upon motivating conditions. Thus hungry rats allowed to explore a maze, but with no food reward, show very inefficient performance. There is little or no evidence that they have learned anything. Yet, when a food reward is intro-

duced, their performance sometimes shows an unusually rapid improvement — a much more rapid improvement than occurs in the performance of rewarded rats which are new to the situation. We therefore infer that, during their exploration, the animals were learning something which their earlier performance failed to indicate.[1]

The processes of perceiving and utilizing information are of course much more evident in human than in animal learning. Take, for example, acquiring the skill to drive an automobile. One observes the performances of others, he reads or listens to instructions, he notes the location and functions of the accelerator, brake pedal, shifting mechanisms, and so on, and he observes that certain of his acts are more effective than others in controlling the car. Such perceptual processes, and the resultant information, are important not only in acquiring the skill to drive but, also, although not so obviously, in the final skilled performance.

The following discussions emphasize overt performance, not because this is all there is to acquiring skill, but because it is all that we can observe or measure. Inferences concerning the underlying perceptual processes receive further consideration in Chapter 8, where theoretical aspects of learning are discussed.

Proficiency in a learned performance is not acquired unless there is some reason for acquiring it. The chief reason for acquiring any skill is inadequacy of present adjustment. As long as the situation is optimal — as long as it provides ready satisfaction of every need — the organism stays, so to speak, in a rut. In research on learning, therefore, we must offer inducements to learn — inducements like food, drink, candy, money, praise, recognition, or escape.

LEARNING IN ANIMALS

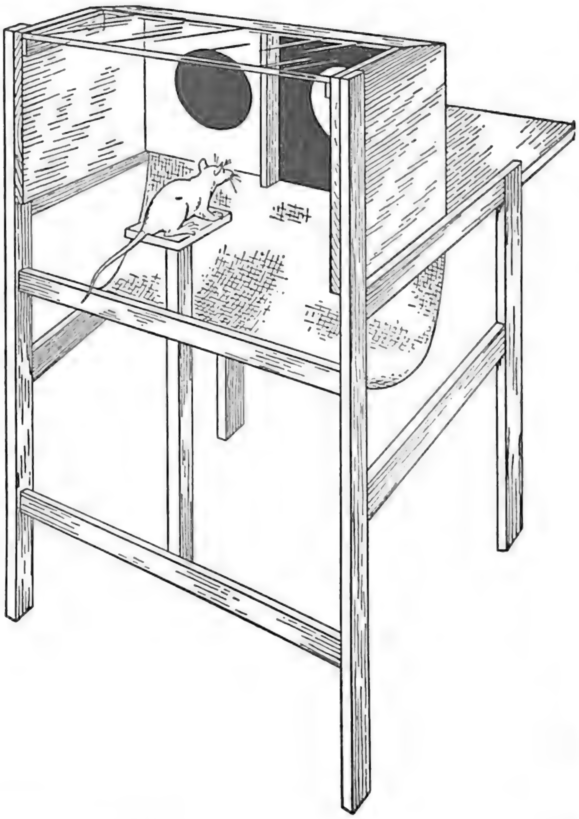
In research on animal learning we disrupt the organism's relation to its environment in some way and, by using suitable rewards or punishments, induce it to make a readjustment. We then study the type of readjustment achieved, how many repetitions are required, how many inadequate responses occur, and, in general, the efficiency with which the new adjustment is learned. When human learning is discussed we shall see that many of the methods parallel those used with animals.

Learning to discriminate

Basically, learning a discrimination is not unlike learning a differential conditioned response, especially in situations involving instrumental conditioning. Learning to discriminate is considered here not because it is a skill, but because this process is basic to learning of all skills. Moreover, the discrimination problem, like problems of greater complexity, requires readjustment of the whole animal to changes in its environment.

In a typical discrimination experiment, the animal is deprived of food until it becomes quite hungry. It is then given an opportunity to obtain food by responding positively to one stimulus and avoiding another that is paired with it, and which varies in position from time to time so that the stimulus and not its location will serve as a sign for food.

A widely used discrimination apparatus is illustrated in Figure 71. The rat is first allowed to explore the apparatus, with the jumping platform close to the apertures which are seen to contain cards. In these preliminaries, the cards are not present. The rat climbs through the openings and finds food on the platform beyond. By blocking one opening from time to time, the experimenter forces the animal to go equally often to the right and left. Then the jumping platform is gradually moved away from the apertures, so that the rat must eventually make a fair-sized jump. Finally the stimuli (forms, brightnesses, or the like) are intro-



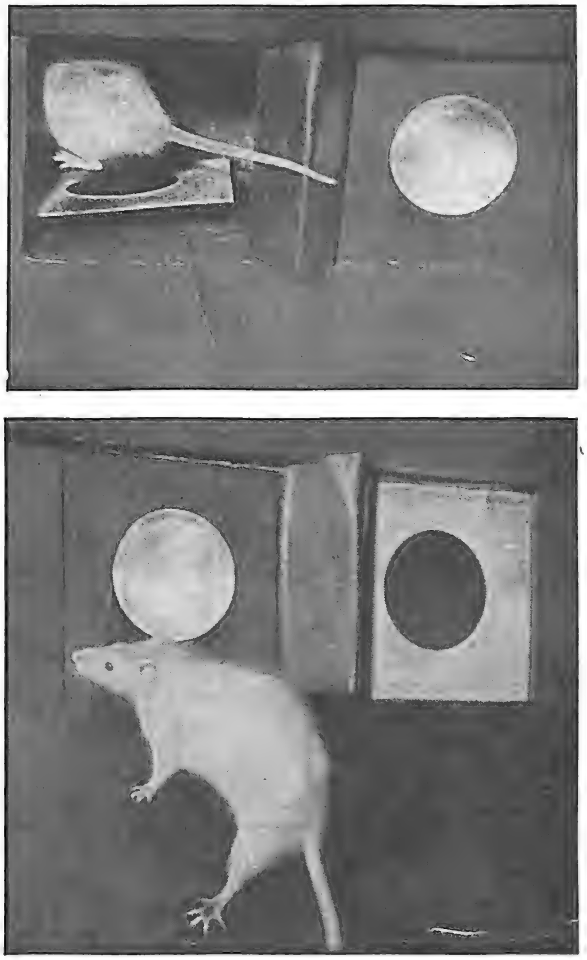
71

Discrimination Apparatus Used with Rats

When the rat jumps against the correct stimulus, he proceeds to the food platform beyond. A jump against the incorrect stimulus, which is locked from behind, brings a fall into the net below. The stimuli are shifted in position, in a chance order, from trial to trial. (After Lashley.)

duced. In the illustration the stimuli to be differentiated are a black circle on a white ground and a white circle of the same size on a black ground. Here the animal receives food only when it jumps at, and knocks down, the black circle. Jumping at the white circle, which is locked from behind, brings a bump on the nose and a fall. The cards are shifted from side to side in a chance order, so that a position habit (jumping always to the right, or left) cannot solve the problem. What happens when the rat makes correct and incorrect responses is illustrated in Figure 72.

The animal usually begins by jumping to the stimuli equally often, but, more or less gradually, it comes to select more often the stimulus leading to food. This stimulus has become a "sign" for food, the other a "sign"



72

A Rat Learning a Discrimination Problem

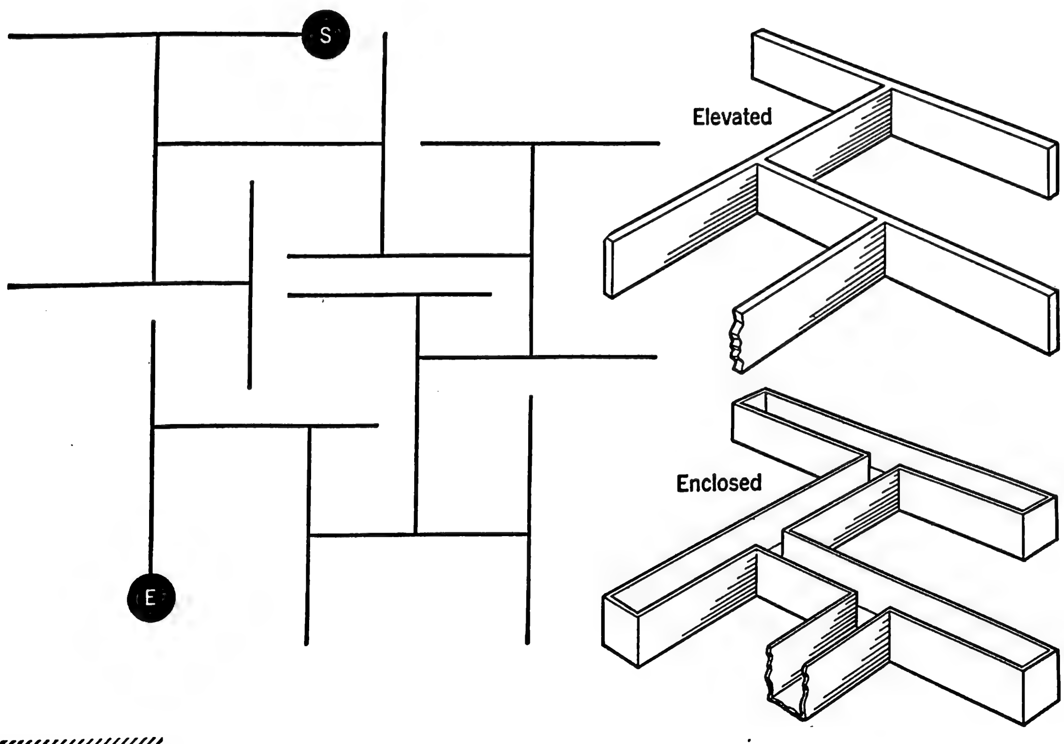
In the top picture, a correct response is shown. The card falls and food is obtained. The lower picture shows an incorrect response, after position of cards has been changed. The rat bumps its nose and falls into a net. (From experiments by Dr. N. R. F. Maier. By Life *photographer Bernard Hoffman.* © Time, *Inc.)*

for punishment. A well trained rat will jump 100 per cent of the time to the positive (in this case, black) stimulus.

Maze learning

The device most widely used to study acquisition of skill by animals is some form of maze. A rat, for example, is deprived of food, water, a sexual partner, or perhaps its litter. The object of which it has been deprived is placed at the end of a maze pathway. One pattern and two forms of maze pathway are illustrated in Figure 73. The front cover of this book shows a circular pattern once extensively used to study learning in rats. The animal is placed at the entrance to the maze and given an opportunity to explore. Deprivation and the strangeness of the situation elicit much activity. Typically, the rat runs hither and yon, starts back toward the entrance, runs in and out of blind alleys, re-enters the same blind alley repeatedly, but eventually reaches the goal. Such apparently random, hit-or-miss, exploratory activity has been called *trial-and-error.*

When we again place the rat in the maze, its behavior is usually much less random than before. The animal loiters less, enters fewer blind alleys, returns to the entrance less often, covers less distance, and gets to the food in less time than formerly. In successive trials, there is gradual elimination of errors (blind-alley entrances), and a gradual fixation of correct turns. There is also a reduction in the total distance traveled and in the time required to get from entrance to



73

A Maze Pattern and Two Types of Paths

This is a multiple-T pattern. Such a pattern is sometimes used with an enclosed and sometimes with an elevated pathway, as illustrated.

exit. Eventually, the rat achieves a level of skill which enables it to go from entrance to exit without error and in the shortest possible time.

If more than one path is open to it, and one of these is much shorter than the others, the animal will most likely learn the shortest.[2] It sometimes happens, however, that the rat running a maze with several possible avenues from entrance to exit, varies its route from trial to trial instead of always following (fixating) a particular path.[3] This fluctuation is more likely to occur when the various pathways are so similar in length that the animal cannot differentiate them in terms of distance.

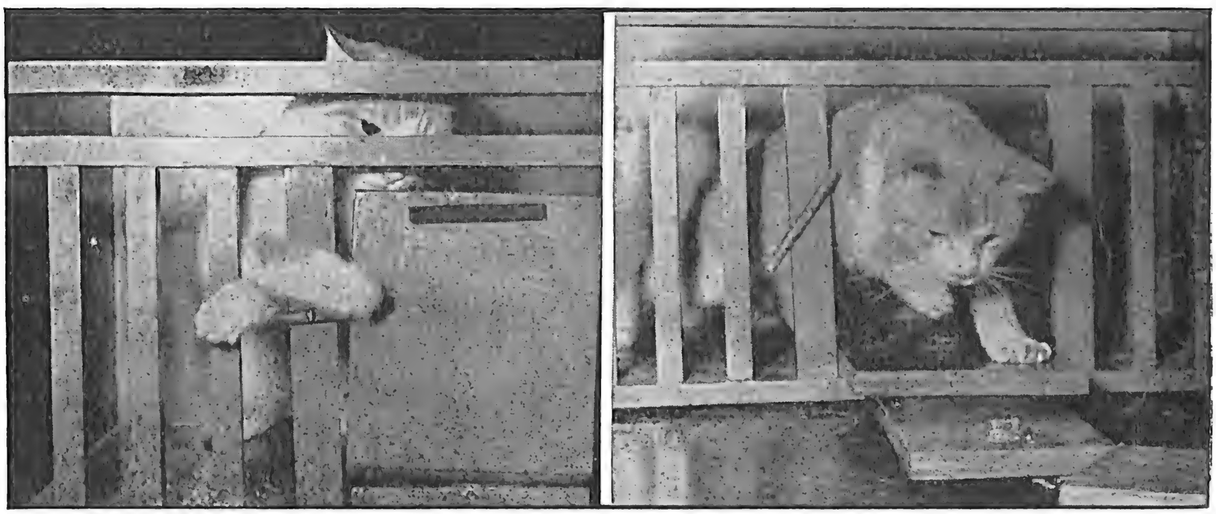
Worms, snails, ants, cockroaches, fishes, frogs, snakes, birds, and a large variety of mammals, ranging all the way from rat to man, have learned maze problems. The complexity of the mazes has varied from a single T-shaped unit, in which either a right or left turn attains the goal, to many units. A simple T-unit is near the limit of learning ability in worms and snails, but ants and the other animals mentioned above learn mazes which have a large number of units.[4]

The problem box

Two problem boxes used to study learning in cats are illustrated in Figures 74 and 75. Similar devices, of varying complexity, have been used to investigate the learning process in a large number of organisms ranging from birds to man.

The animal may be placed inside the box, in which case the motive involved is escape, or perhaps also to obtain food observed through the bars. Quite frequently the animal's task is not to escape, but to get into the box, thus gaining access to food.

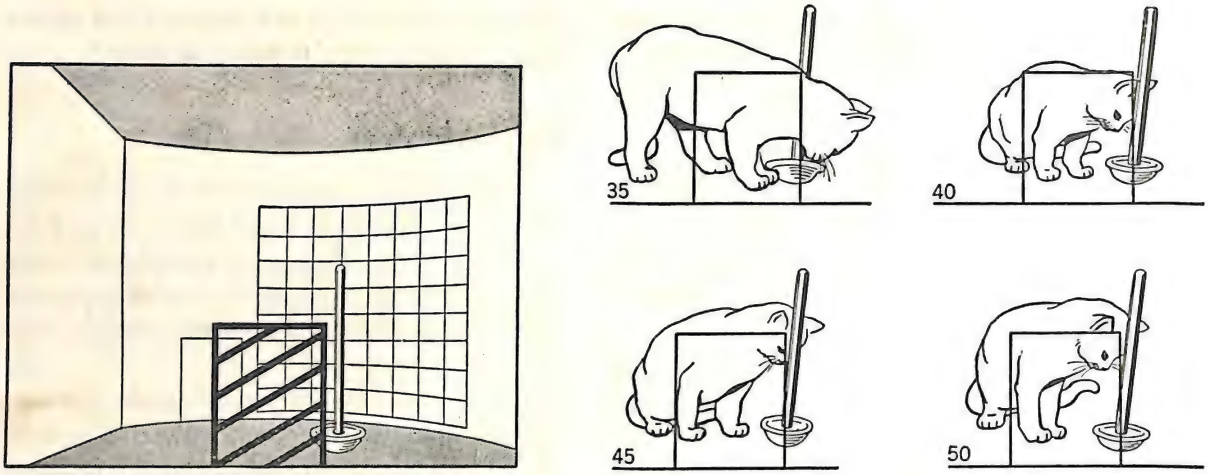
Problem boxes are usually attacked in a trial-and-error fashion similar to that exhibited in maze learning. The animal manipulates various parts of the box until, more or less by accident, it hits upon the correct response or series of correct responses. As in the case of maze learning, there is a gradual elimination of errors and a gradual fixation



74

Cat Opening a Problem Box

Cat gets leverage on cross-bar, and as this is turned the door drops, permitting escape and access to food. (From a study by Dr. C. N. Winslow. Photographs from Pix, Inc.)



75

Another Puzzle Box and Its Solution

The hungry cat was placed in the box and rewarded with fish every time the door opened and it escaped. When the animal pressed against the pole, the glass door (striped for visibility) opened and the cat made its exit. Moving the pole not only caused the door to open; it also activated a camera which photographed the cat, so that exact escape movements were recorded for each trial. The pattern of squares at the side of the entrance door facilitated study of the cat's position as it pushed the pole. Some cats moved the pole by leaning against it, others by a movement of the paw, and still others with the head, as shown. Usually the animal first explored the cage and accidentally bumped against the pole. After bumping the pole several times, apparently by accident, the cat would repeat one of the successful movements. Sometimes this movement would be used repeatedly (fixated) throughout the experiment and sometimes, as in trial 35, there would be some variation. (Arranged from Guthrie, E. R., and G. P. Horton, Cats in a Puzzle Box. *New York: Rinehart, 1946, pp. 10 and 59.)*

of correct responses. After a number of trials, the animal manipulates the correct bolts, latches, or strings without error and in the shortest possible time.

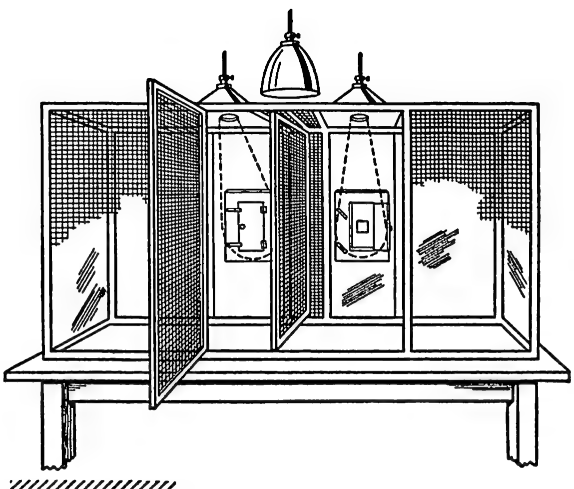
The stereotyped behavior sometimes observed in problem box situations is pictured in Figure 75. This shows how one cat pushed a stick, thus opening a release door, in the 35th, 40th, 45th and 50th trials of an experiment. Intervening trials elicited similar responses to those shown in the last three pictures. In this experiment, the cats moved the pole in a large number of ways (by rolling against it, pushing it with a paw, and so on), but a particular cat usually came to use a more or less uniform procedure, as illustrated. That the cats had limited insight into (understanding of) what was enabling them to escape, is shown by the fact that moving the pole to a new position produced a new problem. The cat went through the former movement, where the pole had been, and only after further training did it again respond effectively to the pole.[5]

Learning by imitating

Monkeys and higher animals sometimes learn simple problem boxes by copying the performance of experts. They are able to learn in this manner, however, only when the basic responses are already in their repertoire. For example, if a monkey has already learned to lift latches, pull strings,

or slide bolts, and these are involved in the problem, but perhaps in different positions or different combinations from those in original learning, the subject may make the proper manipulations after watching another monkey make them. If the constituent responses are completely new, however, learning on this basis rarely occurs, even in man.

What we have been describing is learning by imitation. An apparatus used in imitation studies with monkeys is shown in Figure 76. Observe that two identical cages are placed side by side and that, in the corresponding position in each cage, there are identical puzzle boxes. The imitatee is trained until it is an expert in opening the puzzle box. In the imitation tests, the untrained animal or imitator watches the trained one manipulate a puzzle device, after which it is given an opportunity to manipulate the duplicate device in its own cage. If the monkey fails to open the box within one minute after the demonstration, it is regarded as having failed in that particular test. A new puzzle device is inserted, and the test repeated, perhaps this time with knobs, chains, or strings instead of latches. One of fifteen monkeys tested in this way solved twenty-three out of twenty-four problems by imitation. For the group as a whole, learning by imitation occurred in only 46 per cent of the tests.[6]



76

Apparatus Used to Study Imitation in Monkeys

(Modified from Warden, C. J., H. A. Fjeld, and A. M. Koch, "Imitative Behavior in Cebus and Rhesus Monkeys." J. Genet. Psychol., *1940, vol. 56, p. 313.)*

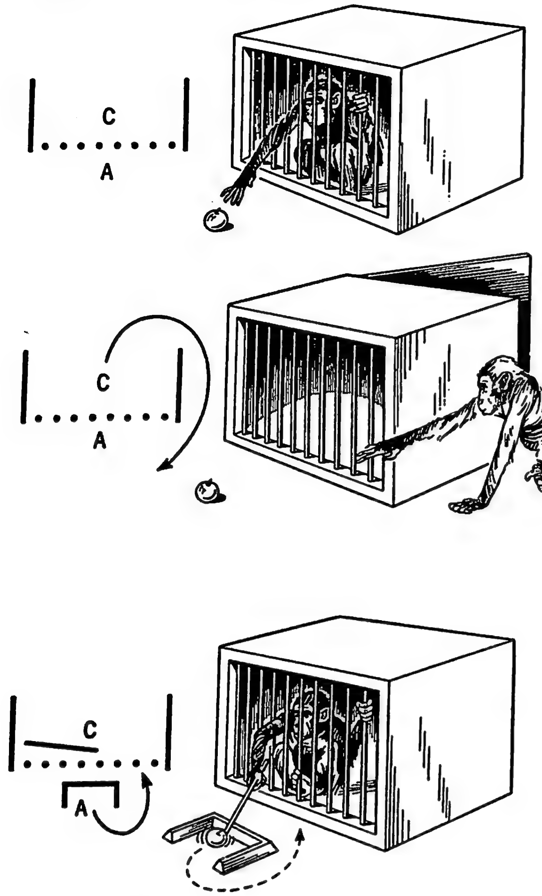
Animals below the level of monkeys have been trained to imitate simple acts like turning to the right or left so that, after many trials, they learn to get a reward or avoid punishment by doing what the animal in front of them does. But it is doubtful whether any of these animals could learn by once passively observing the performance of another, as in the above tests.[7]

The detour problem

A well-motivated animal will go as directly as possible toward an observable and meaningful goal object, but we may change the situation, as in Figure 77, so that what was a direct means of approach is now blocked. When we do this, the animal can solve the problem only by taking an indirect, roundabout, route. In the situations illustrated, where a chimpanzee sees an apple on the other side of a barred enclosure, his efforts will at first be directed toward getting the fruit through the bars. This direct approach being unsuccessful, a bright chimpanzee will go away from the apple, or push it away, in order to circumvent the barrier. Detour problems like these are very difficult for animals to learn. Whether the solution is hit upon accidentally during protracted exploration, or whether it comes suddenly, as it sometimes does in a chimpanzee or child, marks the difference between learning by trial-and-error and learning by *insight,* i.e., by perceiving significant relationships in the situation. The latter, like learning by imitating, is sometimes referred to as *observational learning.*[8]

Use of tools

Learning in monkeys and higher animals is often investigated by use of tool problems.



77

Two Detour Problems

When the hungry chimpanzee is at C *and the apple,* A, *outside is beyond reach, he may persist in attempts to reach the fruit or, if the back of the cage is opened, he may* go away from it, *reaching it by a roundabout route. The other problem is to confine the chimpanzee to his cage, leave a stick lying around, and enable him to get the apple only by pushing it* away from him *and rolling it around the barrier.*

The hungry animal is put in a cage and a lure, such as a banana, is placed at some distance outside. The food can be brought within reach sometimes by using attached strings, sometimes by using a rake, sometimes by using a stick, or perhaps an appropriate combination of sticks. The food may be suspended high above the subject, so that the only means of access is by stacking boxes or swinging on a near-by rope.

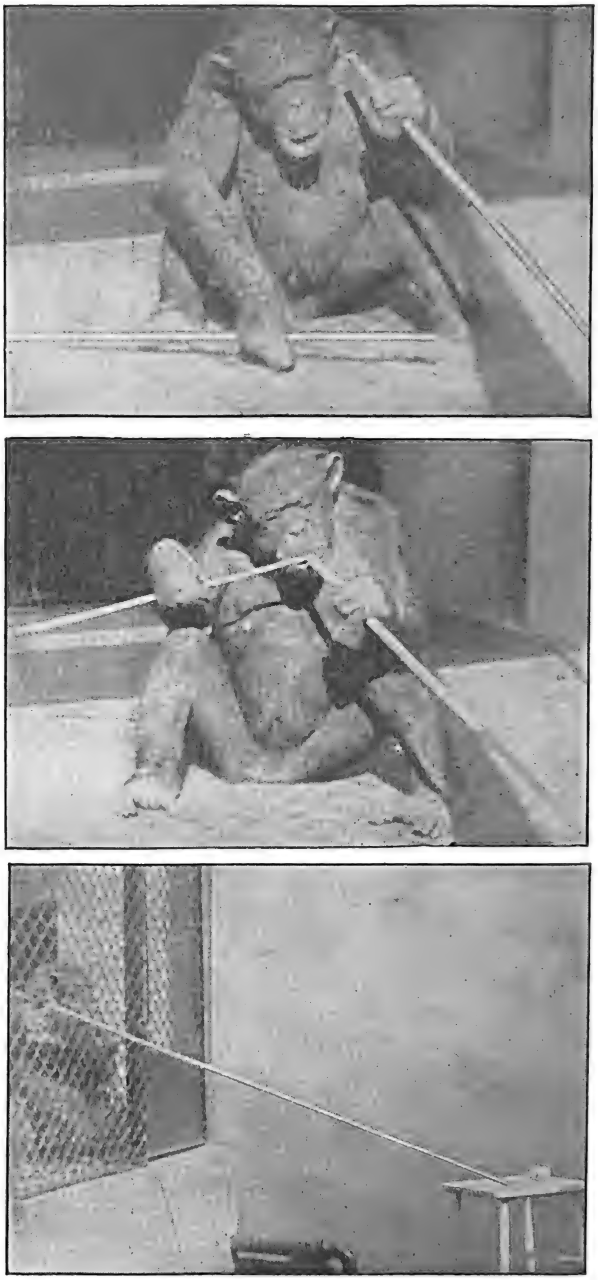
In Figure 78, we see a chimpanzee fitting two sticks together in order to reach food. Neither stick by itself is sufficiently long to reach it. The initial attack on such problems by animals and young children is usually of the overt trial-and-error variety. One stick is used, then the other. One stick may be pushed out with the other until the food is touched. Sometimes the sticks are fitted together, yet without the subject realizing that joined sticks provide a means of solution.

An unusually bright chimpanzee studied by Wolfgang Köhler reacted to the two-stick problem in much the manner described above until, with apparent suddenness, it saw the relation between solution of the problem and the joined sticks.[9]

> Sultan, as before, pushes one stick with the other toward the objective, and as this pseudo-solution does not satisfy him any longer, he abandons his efforts altogether, and does not even pick up the sticks when they are both again thrown through the bars to him. The experiment has lasted over an hour, and is stopped for the present, as it seems hopeless, carried out like this. As we intend to take it up again after a while, Sultan is left in possession of his sticks; the keeper is left there to watch him.
>
> Keeper's report: "Sultan first of all squats indifferently on the box, which has been left standing a little back from the railings; then he gets up, picks up the two sticks, sits down again on the box, and plays carelessly with them. While doing this, it happens that he finds himself holding one rod in either hand in such a way that they lie in a straight line; he pushes the thinner one a little into the opening of the thicker, jumps up and is already on the run toward the railings, to which he has up to now half-turned his back, and begins to draw a banana toward him with the double stick."

This behavior was repeated on several occasions after Köhler was called to the scene.

Such sudden solution of a problem, as we saw in the case of detour behavior, is des-



78

Chimpanzee Joining Sticks so that Food may be Reached

Finding that food is inaccessible with one stick, the chimpanzee picks up the two sticks, fits them together, and pushes the combined sticks toward the food — a dish of ice cream. After pushing the end of the double stick into the ice cream, the chimpanzee withdraws it and licks off the delicacy. (From the film "Monkey into Man," by Huxley and Zuckerman. Courtesy of Walter O. Gutlohn, Inc., Educational Films, American distributors.)

ignated *learning by insight.* Apparently, the animal grasps the relation between different relevant aspects of the situation. This is perhaps synonymous with what, in human beings, is known as "getting the idea" or "seeing the point." One psychologist calls it the "Aha experience."

Only limited insight is possible in typical maze situations where but a small portion of the pathway is apparent at one time. This is true also in certain problem situations where significant aspects of the mechanism cannot be perceived. Sudden learning which suggests insight has been observed most often in tool-using situations, because, in these, all aspects of the problem are presented simultaneously. Such situations make it relatively easy for the subject to "put two and two together."

The predominant use of maze and puzzle-box situations by early American investigators of animal learning, and the use of tool situations, where all relevant aspects of the problem are visible, by German psychologists, once led Bertrand Russell [10] to remark that to all appearances,

> Animals studied by Americans rush about frantically, with an incredible display of hustle and pep, and at last achieve the desired result by chance. Animals observed by Germans sit still and think, and at last evolve the solution out of their inner consciousness.

Insight is rare in animals, not quite so rare in children, and quite common in human adults. In human adults certainly, and perhaps also in animals and children, insight is often preceded by implicit trial and error, a process which involves thinking of the various possible moves instead of actually making them. But animals are unable to report what is going on inside of them, hence we

are unable to say what implicit processes are associated with a performance like Sultan's.

HUMAN LEARNING

As we have already suggested, much of the research on human learning parallels that on animals. Discrimination problems, mazes, puzzle boxes, tests of imitative ability, detour problems, and tool-using situations have been used extensively at the human level. Usually, however, they have been complicated or otherwise modified to adapt them to human use. In addition to the problems used with animals, human beings have been called upon to demonstrate how they learn a wide variety of complex skills like archery, fencing, flying a plane, typing, and sending and receiving code messages.

Among all devices used to study human, as well as animal learning, mazes predominate. One reason for this emphasis on a type of behavior somewhat removed from activities of everyday life is that all individuals who learn a maze pattern devised by the experimenter "start from scratch." They may have learned to throw darts, to shoot arrows, or to perform many other acts, but none of them has learned to find his way through this particular maze pathway. If we compared individuals in learning to throw darts, for example, those who had already acquired some proficiency would have an advantage over the others. If we used almost any other everyday form of activity, the same situation would arise. On the other hand, maze performance is a novel skill. This is an important point, not only in comparing the learning ability of one individual with another, but also in comparing the effectiveness of different conditions and methods of learning. It would be impossible to equate control and experimental groups for training under different conditions if some individuals had already, and to an unknown degree, learned the activity used to measure learning.

Human maze learning

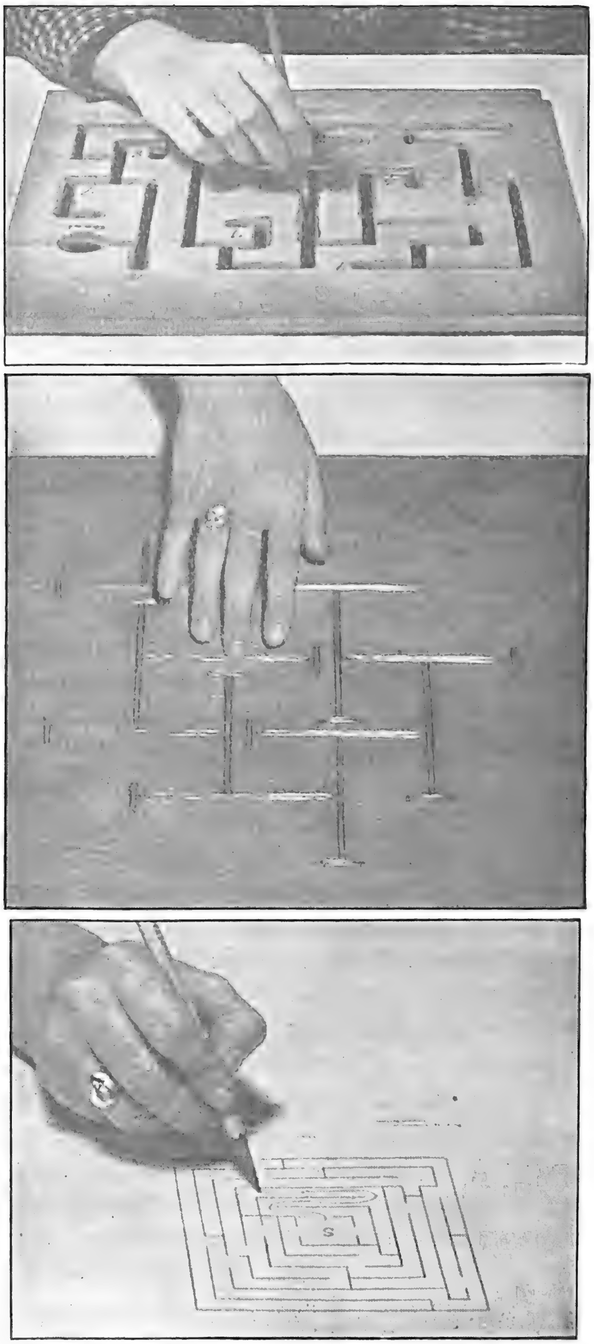
Mazes for research with human subjects may be made sufficiently large for the subject to walk through them. It is customary, however, to use small mazes which the subject traces by moving a pencil along a grooved path, by moving his fingertip along a raised wire path or by tracing printed forms with a pencil. Each of these varieties is illustrated in Figure 79.

Stylus and finger-relief mazes are learned while the subject is blindfolded. This places him somewhat in the position of an animal running the enclosed-alley maze, for he perceives only a small portion of the maze at a time, and is unable to use insight to any marked degree. Paper mazes, on the other hand, are more like the open-alley maze used with animals, but they are so complicated that, even though the subject can see the whole layout, he cannot immediately discern the correct pathway. He must "figure it out" either by overt trial and error, by observing and relating its details, or both.

Human learning in stylus and finger-relief mazes does not, as a rule, proceed any more efficiently than learning of comparable maze patterns by white rats. This is very rudely brought home to students who, after watching rats learn a maze and being irritated or amused at the lack of insight displayed, find themselves using an overt trial-and-error approach, retracing, re-entering blind alleys, and, in general, doing almost everything a rat does. The number of trials required to learn, the number of errors made, and the time consumed, are not greatly different in rats and college students. Sometimes the rats come out slightly ahead and sometimes the students.[11]

There are certain aspects of the situation that may favor the human being, and certain others that may favor the rat. Let us see what these are:

The human subject perhaps has an advantage in that, after a few trials, he can formu-



79

Three Human Mazes

This stylus maze (top) is one devised by Foster and Tinker. Finger-relief mazes (center) often have a single wire. Observe that this double wire maze has a multiple-T pattern. The pencil-and-paper maze (below) is from the Porteus Maze Test.

late certain aspects of the problem verbally. He perhaps says to himself, "I made that mistake before. I'll have to watch my step next time I get into this region"; or, "If I keep the stylus pressing against the right-hand side at this point, I'll not miss that correct pathway." He may develop a visual representation of the pathway. After he has learned a maze pattern blindfolded, the subject can often draw a fairly good picture of the path. His superior reasoning ability would give the human subject a great advantage if the maze involved some logical pattern which he could figure out. But mazes like those under consideration usually do not involve any logical pattern. The individual is forced to use elementary processes comparable in many respects with those used by rats.

Motivation, on the other hand, is probably in favor of faster learning by the rat. A hungry rat running the maze, or a rat swimming it, acts as though life itself depended on getting to the end. No human subject is so intensely motivated while learning a maze. He learns it, in the first place, because he is required to learn it or because he wishes to oblige the experimenter. While he is learning, the human subject may be motivated by a desire to get through with his task as soon as possible so that he may do something more interesting, he may work hard for fear that the experimenter will think him stupid, or he may go through the trials in a routine and disinterested manner.

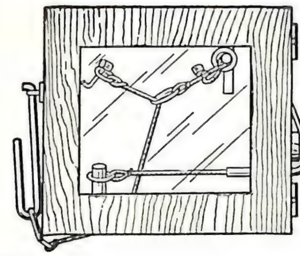
The rat is not only better motivated, but it is less distractible than man. Instead of giving full attention to the task, human subjects often respond to extraneous things—like the sound of planes overhead, voices down the hall, and their own personal discomforts. As the task becomes routine, they may even day-dream — their thoughts far away from the learning situation.

Moreover, the rat usually learns the maze with one trial a day for several days, where-

as the human subject usually learns it at one sitting—with massed rather than distributed practice. Massed learning, as will be observed more fully in the next chapter, is usually not so efficient as distributed learning.

Poor motivation, distraction, and massed practice, all interfere with efficient learning. In the maze-learning situation these may easily cancel whatever advantage comes from man's superior intelligence.

Pencil-and-paper mazes, like the one illustrated in Figure 79, are hardly comparable with the usual varieties of maze. The subject may start tracing with a pencil, and retrace wherever necessary, until he reaches the goal, but this is not the characteristic approach. Learning of such mazes is likely to be observational rather than manual. The subject looks the situation over and, with his eyes, follows one possible lead after another. When the correct pathway is evident, he then takes pencil in hand and traces it. Trial-and-error is involved here, as in other forms of maze learning, but it is likely to be implicit more than overt. In other words, the individual largely thinks his way through the maze.



80

The Healy Puzzle Box

The box has holes at the sides through which the small end of a buttonhook may be inserted. Application of the hook to the rings, in the proper way and in the correct sequence, releases the cords and allows the box to be opened.

Problem boxes

Human solution of problem situations is often in marked contrast with that of animals. Problem boxes like those already described are usually solved at a single glance by human subjects. Thus, puzzle boxes used to study learning in human subjects must be much more complicated than those used to study learning in animals.

Part of man's ability to solve problems more complicated than those solved by animals below him comes from his greater manual dexterity. More important, however, is his better ability to learn by observation, to see relationships, and to reason.

Consider, for example, the problem box shown in Figure 80. This apparatus is probably too complicated for any animal below man to manipulate appropriately. It must be opened by inserting the buttonhook into appropriate holes, placing the hook over certain rings, and lifting them off pegs. But the process requires something more than motor dexterity. One must observe the holes; whether the buttonhook will fit into them; whether it will enable the rings to be loosened; and the sequence in which the rings must be lifted. If the problem is to be solved readily, careful observation and a certain degree of insight are necessary. A chimpanzee would probably not even grasp the nature of the problem. He might, to be sure, make a simple problem out of it by smashing the box. Human idiots fail to grasp the nature of such problems. A normal human subject, however, keeps within limits set by the instructions. He undertakes to open the box with the buttonhook alone, and not to break the glass cover or any of the cords to which the rings are attached.

In solving such problems, human subjects sometimes exhibit a more or less random, more or less trial-and-error, approach which is clearly apparent to any onlooker. They pull the string with the buttonhook, turn the box over and around, and pull at the latch. Then, suddenly, they get the idea of insert-

ing the hook into a hole and trying to get at the rings in that way. They try loosening one ring, but soon discover that another must be loosened first. This sort of behavior continues until, perhaps after an insight or two, the subject gets the box open.

It occasionally happens, on the other hand, that a subject will solve the problem on an observational basis entirely. He looks the situation over and makes no overt move until satisfied that he can open the box without error.

I once handed the Healy puzzle box to a girl in elementary psychology hoping to demonstrate trial-and-error learning to the class. But she looked at the box a minute or so, then opened it swiftly, without a false move. Upon being asked how she did it, the student replied that she "figured it out." She thought of one move after another, some correct and some incorrect, but made no overt response until she had "figured it out." After this implicit trial-and-error process reached completion, the student put into practice what she had learned observationally. It may have seemed to some that she learned the solution by a sudden "flash" of insight rather than by trial-and-error. Much of the sudden learning observed in man and animals may be the outcome of some such implicit trial-and-error process.

81

Child's Reaction to a Detour Problem

This baby has not yet advanced to the stage where it can discern the need for an indirect approach. It persists in its attempt to get through the glass to the lure beyond. (From a demonstration given by Dr. Lois Bellinger of Columbia University. Photo by Martha Holmes, courtesy of Life. © Time, *Inc.)*

The detour problem

Young children, like animals, find detour problems especially difficult. The eight-month-old in Figure 81 is trying to get the doll directly, with apparently no insight into the correct solution. This child, although mentally advanced for his age, did not solve the problem. To an older child who had experienced similar problems before, this would be no problem at all.

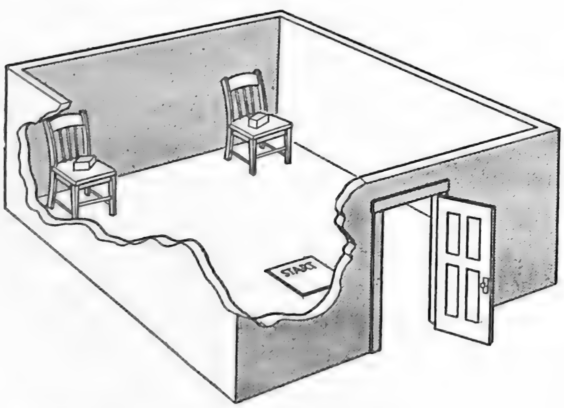
Similar detour problems are faced by children in adapting to many situations of everyday life. Take, for example, learning to sit on a chair. This is at first quite difficult. In order to sit down, the child must turn away from the chair and sit on something it cannot see. This is comparable, psychologically, to going away from something, or pushing it away (Figure 77), in order eventually to get it. To solve such problems, the child must act, not in terms of the immediately present stimuli alone, but in terms of an implicit "restructuring" of the situation.[12] He must, in other words, respond by applying "what he knows." Until he gets knowledge of such situations, through his own explorations and by observing others, he cannot solve them. Adults have little or no difficulty with such problems because they can draw upon relevant past experience.

Learning by imitation

Human beings may learn a great deal by observing and attempting to copy the performances of others, but they must first learn to imitate and, in order for the example to be effective, it must utilize habits already learned.

We have shown (p. 129) how a baby learns to imitate its own sounds, then sounds made by others. Another illustration of learning to imitate, but on a more complex level, is found in an experiment with forty-two first-grade children. The situation is pictured in Figure 82. One child (the leader) was told which of the two boxes to open. If he opened it, a piece of candy was found. Another piece in the box was to be left there. The other child (imitator) was rewarded with the second piece of candy if he opened the same box as the leader. He was not rewarded if he went to the other box. In any test, both children stood at the place marked "start." On the first test, the children were told: "Here are two boxes, there and there. Here is a piece of candy. You are to find the candy. He gets the first turn. Then you get a turn. If you don't find it the first time, you will get another turn." The leader always had his turn, then the imitator. The position of the candy varied, of course, from one box to the other in a random order. Twenty per cent of the children imitated on the first trial. Some or all of the 80 per cent who went to the other box may have done so because, seeing the leader get candy out of a box, they reasoned that there would be no more in that box. After an average of three trials, the second child copied the performance of the first child. When the situation was changed, so that the children were confronted by four boxes arranged at the corners of an imaginary square, 75 per cent of the subjects imitated. This demonstrated that they generalized, or transferred to a different situation, the tendency to imitate which they had learned in the first situation. Other children were taught not to imitate. They were rewarded for not doing what the leader did. Their non-imitative tendency transferred 100 per cent to the new situation.[13]

In this experiment it is noteworthy that the children given an opportunity to imitate already had within their response repertoire the basic activities required. In other words, they could all walk toward a box, open it, and lift out what was in it. A child who could not already do these things would obviously fail to imitate. This point, quite obvious here, is perhaps not so obvious, although even more important, when skills of far greater complexity, like learning to dismantle and reassemble a watch or some other complex device, are involved.



82 **The Situation Employed to Teach Children to Imitate**

(From Miller, N., and J. Dollard, Social Learning and Imitation. *New Haven: Yale University Press, 1941, p. 124.)*

COMPLEX MOTOR SKILLS

Learning of many athletic, industrial and professional skills is today facilitated by moving picture demonstrations of skilled performance. The effectiveness of such demonstrations, as in the illustrations just

given, depends upon their use of basic skills already present in the observer.

Another important factor in learning complex skills through observation is verbalization — talking to oneself. An investigation with fifth grade school children illustrates how this factor facilitates learning as the result of a demonstration. The skill to be learned was assembling a three-dimensional cross from six oblong blocks, five of which were notched in the middle on one of the two sides. The final step, of a total of six, was to insert the sixth block so that it locked the others together. None of the children had ever seen the problem before. The procedure with each child was as follows: The demonstrator arranged the pieces in a certain order, assembled them, disassembled them, then gave the pieces to the child for its first trial. If the subject failed to assemble the blocks within 60 seconds, another demonstration was given. This procedure was repeated until the blocks were assembled or until 25 to 30 trials had been given.

Of 25 children required to count to 100 by twos while watching the demonstration, only 3 learned. Twenty-two of a comparable group, which described what the demonstrator was doing, learned the problem in an average of 16 trials. When the child was silent, but the demonstrator described what she was doing, all of a group of 25 learned, and they did so in an average of 14 trials. Another group of 25 all learned the problem, and in an average of 12 trials, when they described what the demonstrator was doing and she corrected their verbal descriptions. Children who had difficulties in verbally describing the demonstration were especially handicapped in copying what they had witnessed. The fastest learners were, in general, those who could give a good verbal account of what the demonstrator was doing.[14]

Learning a skill through witnessing a demonstration involves the following processes:

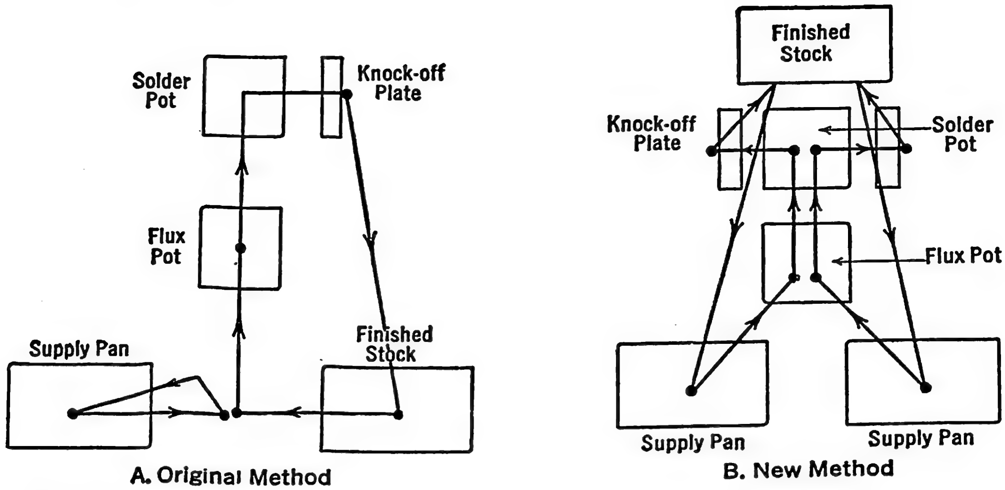
Grasping the meaning of the performance, trying to fix images of how the model looks in each step of the process, and perhaps most important of all, formulating silent verbal directions for the steps in the process. The observer may also derive some benefit of slight imitative movement of arms, legs, and hands which amount to an abbreviation of immediate imitation.[15]

Regardless of how the subject responds while witnessing an actual or a movie demonstration of a complex skill, the sample performance has at least two decided advantages over a pure trial-and-error approach.

(1) It shows the correct performance, thus enabling the learner to save time and effort which might otherwise be wasted in making incorrect approaches. Suppose, for example, that you were a Hottentot who had never seen or heard of a bicycle — that you had not the least idea what the entire device or its various mechanisms were for, but you were shown a moving picture of a man riding a bicycle. Then, although you would be far from acquiring skill in riding, you would at least know that the device was for transportation, that one sits on a certain part rather than another, and that moving it requires pushing the pedals with the feet. Human beings are often called upon to learn industrial skills just as foreign to their past experience as cycling is to the past experience of the Hottentot. In such instances, seeing a skilled performance saves a great deal of time which would otherwise be spent in trial and error.

(2) Observing skilled performance not only gives general orientation like that described, but it also gives the observer certain insights at the start which, if he ever acquired them during practice, might come only after a long process of trial and error.

Observe, for example, the two methods of performing an industrial operation, illustrated in Figure 83. The original method, probably hit upon in a blind trial-and-error fashion, enabled the worker to solder-coat five blocks per minute. The new method,



83 **Comparison of an Inefficient and an Efficient Method of Performing an Industrial Operation**

(From Poffenberger, A. T., Principles of Applied Psychology. *New York: Appleton-Century, 1942, p. 387. Adapted from Morgensen A. H.,* Common Sense Applied to Motion and Time Study. *New York: McGraw-Hill, 1932, p. 58.)*

worked out by an "efficiency expert" and taught partly by demonstration, made it possible for the worker to solder-coat more than nine blocks per minute. In the old work pattern, both hands (represented by dots) were used, but the left merely reached into the supply pan. The other hand performed essential operations. In the new method, however, both hands simultaneously reached the supply pans, each carried a block to the flux pot, each to the solder pot, each to the knock-off plate, and each to the stock pile. It is obvious that the insight which underlay this new arrangement of materials, this greater use of the left hand, and this more efficient use of the right hand, could not, if learned at all, be acquired by the worker as readily as by demonstrational means. By such means he does not have to get the insights himself, they are given to him from the start.

A blind trial-and-error attack on problems is often called *practice,* to differentiate it from *training,* where skilled performances are observed, and the learner is given certain instructions concerning his performance, perhaps even taught the principles of operation involved.[16]

VERBAL SKILLS

Some motor skills are acquired by man partly through memorizing. That is to say, he intends to remember which acts lead to the best results, what he has observed in a skilled performance, and what he has been told by his instructor about operation of the tool or machine in question. Most verbal skills acquired by older children and adults are clearly learned by memorizing. The individual repeats the material with the intention to recall or recognize it later.

Learning to speak

Speaking is a complex motor skill, as well as a symbolic or verbal one. It is acquired partly on the basis of reflex vocalizations which appear during early infancy, but also on the basis of imitation and trial-and-error activity.[17]

Ability to make combinations of sounds which closely approximate those of adults (namely, "doll" instead of "da," the original vocalization) develops gradually. There is no doubt that maturational factors are involved in this development. Vocalizations produced by adults cannot be copied by the child until auditory-vocal mechanisms, including their cerebral connections, have sufficiently developed. Nevertheless, it is obvious that children learn to speak, just as they learn other manipulative habits. Saying the word "doll," for example, calls for a complex integration of lung, throat, mouth, and tongue movements in properly timed succession. The sound *d* is produced when the tip of the tongue is placed between the slightly open teeth in a certain way, and air is expelled from the lungs. Saying *o* calls for an appropriate manipulation of lungs, vocal cords, tongue, and mouth, as well as of resonance cavities within the throat and mouth. The *l* sound requires manipulation of lungs, vocal cords, tongue, and mouth. Saying "doll" in the adult way calls for a rather definite temporal patterning of these movements. Such patterns are gradually acquired. Adequately stimulated by his fond parents, and later by formal teachers, the child vocalizes in a trial-and-error fashion, until he achieves the acceptable patterns. Thus he learns to say "doll" instead of "da," "stomach" instead of "tummy," "sugar" instead of "fugar," "light" instead of "yite," "elephant" instead of "fant," and so on.

Memory experiments

Verbal skills frequently involved in laboratory studies of learning include recitation of poems or narratives; recitation of lists of words, digits, syllables, or other symbols; and substitution of one kind of verbal material for another, for instance, substituting digits for words or forms. Very little need be said about such materials at this point, for they will be dealt with in more detail in the chapter on remembering, which concerns not the process of memorizing as such, but what is retained after such a process.

The most useful type of verbal material for experimental purposes is the nonsense syllable, or some modification of it. Ebbinghaus pointed out that poems, narratives, words, digits, and similar meaningful material give certain individuals an advantage over others. If one has already learned a poem, for example, his laboratory learning of it does not start from scratch. He has an advantage over somebody who has never before seen or heard the poem. The problem is the same as the one considered in relation to motor skills, where the maze was found to have advantages, for scientific work, not possessed by activities more in line with everyday skills.

Typical nonsense syllables are *fej*, *guk*, and *ril*. Such syllables, of which an almost endless variety may be devised, are usually arranged in lists, either singly or paired. In the first instance the subject merely learns to reproduce them in order, as he would a list of words. This is the simple recall method of learning. In the second instance, however, he learns to repeat the paired syllable when its partner is presented alone. This learning of paired associates is like learning vocabulary lists, where the foreign word is presented and one gives its English equivalent, or vice versa.

A type of apparatus widely used to expose syllables, or other verbal materials, either singly or in pairs, at controlled time intervals, is shown in Figure 84.

Substitution learning

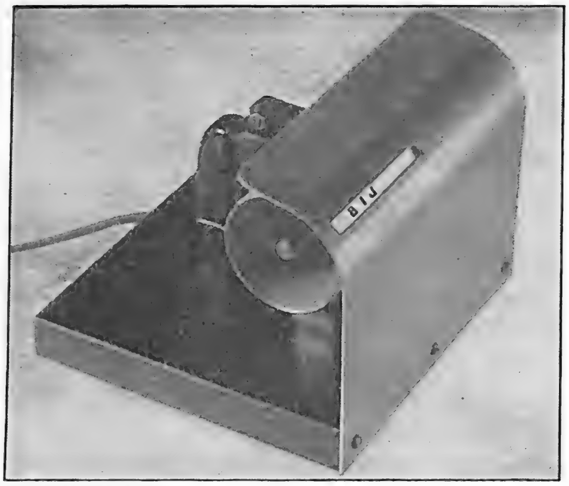
Learning to substitute one symbol for another is a variety of code deciphering. The subject may be presented with a page of material like the following:

LAXDOCQBGY
1 2 3 4 5 6 7 8 9 10

YLOQBCDAGQOBXLYCDXQGYDXOA

LXBOAOXDXALDBGQYOCDXLGCDQ

At the word "Go," he uncovers the page and begins substituting below each letter



84

A Memory Drum

The material to be memorized appears in the slit. (Courtesy of Ralph Gerbrands, Arlington, Mass.)

the number indicated in the code at the top. The subject continues to do this until time is called. On the next trial he is given a duplicate sheet, and the procedure is repeated. After a few trials, the subject has memorized the key, and further improvement depends merely upon speed of substitution. Substitutions much more complicated than in this sample are often used in such research. For example, learning of the international Morse code has been subjected to intensive psychological investigation, resulting in discovery of procedures which greatly facilitate its acquisition.[18]

LEVELS OF COMPLEXITY IN HABIT FORMATION

Many complex skills, both motor and verbal, involve an integration of simpler skills. Some involve successively higher stages of integration as learning proceeds. They are, for this reason, referred to as *habit hierarchies.*

Take typing, for example. One first learns to hit the correct keys. These learned responses may be designated *letter habits.* After habits of striking the correct keys have progressed to the point where the individual is fairly proficient, he finds that he is developing *word habits.* Letters like T, H, and E, instead of eliciting noticeably separate responses, arouse a single response. The individual looks at the word "THE" or thinks it, and the separate responses seem to take care of themselves. After a while, *phrase habits* appear. Common phrases like "Very sincerely yours" are typed without the typist having to pay any attention to either the separate letters or the separate words. The situation in typing may be presented schematically as follows:

Letter habit	T H E B O O K I S D U E
Word habit	T H E B O O K I S D U E
Phrase habit	T H E B O O K I S D U E

Flying a plane, or any similar motor skill, first involves learning to use the separate controls correctly. As this series of separate habits is being mastered, however, the student is also learning second-order habits, like coordinating the movements of stick and rudder bar. With further practice, there develops a smooth patterning of movements, such as those made in doing complicated maneuvers.

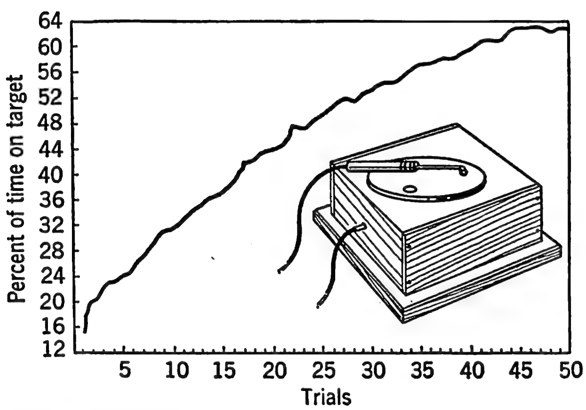
After complicated skills are practiced for a long while, they tend to run their course automatically. There are many examples of this in everyday life. Think of the concentrated attention that one must give to riding a bicycle for the first time. One is aware of movements made in balancing the vehicle, in guiding it, and in working the pedals. After considerable practice, however, these balancing, steering, and pedaling activities take place automatically — one does not have to think of them. He may day-dream or engage in a conversation while riding. Eventually, he rides with as little thought as is involved in walking.

LEARNING CURVES

Learning curves illustrate progress in the acquisition of skill by showing the rate at which errors, for example, are eliminated or correct responses fixated. Practice periods, trials, or uniform intervals, after which performance is sampled, are represented along the base (abscissa) of the graph. Errors, time, correct responses, or other indices of progress or lack of progress are represented at the left side (ordinate) of the graph.

Figure 85 is a graphic record of the average progress made by 153 men in learning to keep contact with a moving target on a pursuitmeter, which is also illustrated. The target, about the size of a dime, revolved at the rate of one revolution per second. The stylus, whose tip was to be held on the target for as long as possible in each ten-second test, was hinged so that no pressure beyond its own weight could be applied to the target. On the ordinate of the graph is shown the per cent of time, within each ten-second period, that contact was maintained. The range of scores was from around 1.2 to around 6.4 seconds. Trials are represented along the abscissa. Fifty trials, of ten seconds each, were given. The curve shows rather steady progress in acquisition of skill. Learning curves for individuals usually show much more fluctuation than group curves.

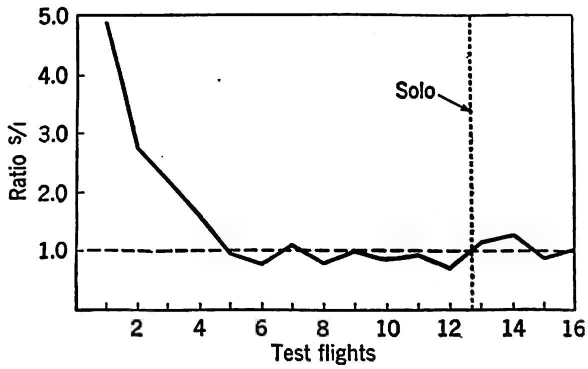
When errors, or unnecessary movements are plotted, one obtains a falling curve as learning progresses. This is illustrated in Figure 86, based upon excess movements made in controlling the elevator movements of an airplane while flying a standard course. Here we plot test flights over the standard course, rather than practice time. Each test



85

Pursuitmeter and Curve Showing Progress in Acquisition of Skill

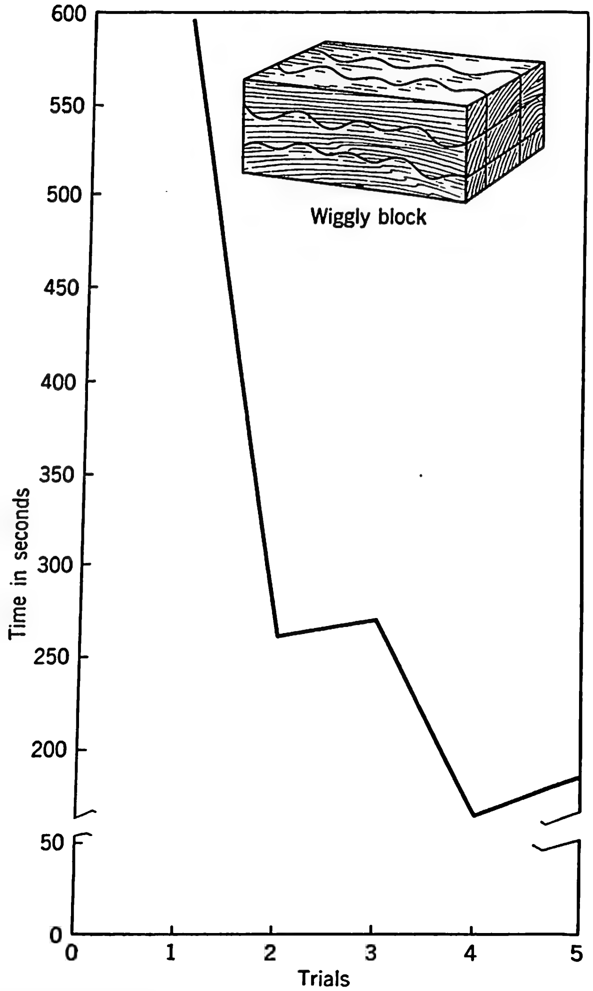
The subject's task is to keep the small metal ball at the end of the stylus on a dime-sized metal disk as it revolves at the rate of one revolution per second. The time that contact is maintained in each 10-second test is recorded on a chronoscope. Observe that contact is first maintained for an average, per 10-second trial, of only 1.4 seconds. After 50 trials, the average time of contact is 6.3 seconds. (Adapted from Buxton, C. E., and K. W. Spence, An Appraisal of Certain Tests of Pilot Aptitude. *Civil Aeronautics Administration, Division of Research, Report No. 64, 1946, pp. 7 and 17.)*



86

Reduction of Elevator Movement While Learning to Fly

This curve was plotted from automatically recorded elevator movements, as measured by a special line-tracing instrument. It shows ratios representing the amount of movement produced by the student divided by that produced by a skilled flyer covering the same course under comparable flight conditions. The plane was a Piper Cub. (From Kellogg, W. N., "The Learning Curve for Flying an Airplane." J. Appl. Psychol., *1946, 30, p. 438.)*



87

A Learning Curve for Solving the Wiggly Block Puzzle

flight came after a ten-minute period of practice flying (plus ground instruction) and represents a sampling of progress. The ordinate shows that the student began by moving the elevator about five times as much as the instructor moved it while flying over the same course under comparable wind and weather conditions. Actual movements were recorded by a special instrument in the plane. By the fifth test flight, overcontrolling ceased; the amount of movement reached the level exhibited by a skilled flyer. It stayed around this level, except for a slight rise after the solo had been flown. Other indices of flight skill, in addition to operation of the elevator, show somewhat similar trends.

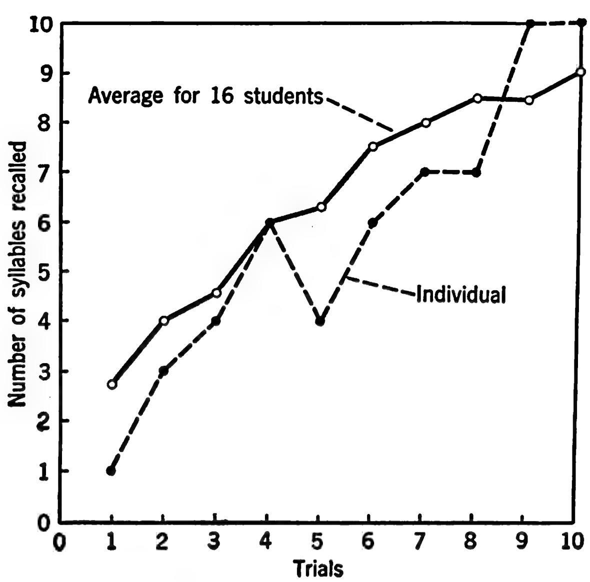
When we plot the time per trial for reaching the end of a maze, opening a problem box, solving a puzzle, or achieving the culminating act of any skill, the curve drops as a function of practice. The decrease in time is usually very gradual, but when insight into the nature of the problem is possible, the curve sometimes drops rapidly, as does that of Figure 87. This curve represents learning of the wiggly block by one student. The initial attack on the problem, which requires the subject to combine the various blocks scattered before him, is usually in the nature of overt trial-and-error. In other words, the subject actually manipulates the pieces. But he may realize, before or while assembling them, that the block that is wiggly on all sides must go in the middle, that the blocks wiggly on three sides must go in the center of a side, and that the blocks with two flat edges must be corner blocks. In other words, he attacks the problem partly through implicit trial and error (see pp. 146–147). Insights such as we have mentioned often lead to a sudden decrease in time, as between 600 and 250 seconds in the graph. When time scores for the puzzle box shown in Figure 80 (p. 146) are plotted, the curve drops even more precipitously. In one subject it dropped from ninety-five seconds in the first trial to only sixteen in the second trial.

A large sudden decrease in time, or a sudden increase in efficiency, is usually taken as basis for the inference that insight has occurred. Many problems, like learning a stylus maze, keeping contact with a pursuitmeter target, controlling the elevators of a plane, or learning to type, must be attacked through overt trial-and-error, but supplementary implicit processes may bring insights which speed the learning process.

The physiological limit

Learning curves tend to approach a limit beyond which performance cannot improve. The physiological limit, in the case of error curves, is set by the problem itself. One cannot make less than zero errors, hence the curve ceases to change when the error score is consistently zero. In the case of time curves, the physiological limit is approached as the individual gets to the point where he cannot manipulate any faster. He is like the skilled runner whose legs cannot go faster. When correct responses are plotted, the curve cannot rise above the place where performance is perfect. Thus, in the curves for learning of nonsense syllables represented in Figure 88, the highest possible point is that at which all syllables in the list are correctly reproduced.

Often a skilled worker fails to attain the full efficiency of which he is capable. He acquires sufficient skill to "get by" and then stops. It might seem, at first glance, that he has reached his physiological limit. But stiffer competition, higher standards of performance demanded by his teachers or employers, or the introduction of bonuses for output above a certain level, lead him to improve his efficiency. The learning curve then rises, showing that the physiological limit was not reached. In a well-known industrial study, for example, experienced typesetters increased their average output more than 40 per cent after a bonus system, dependent upon output above a certain minimum, was introduced.[19]

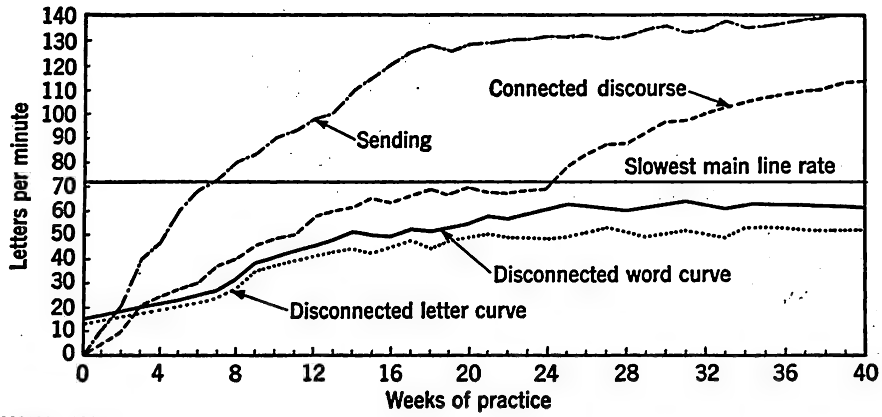


88 Curves Based upon the Learning of a List of Ten Nonsense Syllables

Plateaus

As we have just suggested, learning curves sometimes exhibit a leveling off, followed by a further rise. A stretch of little or no apparent improvement, followed by further improvement, is known as a *plateau.* It may be produced by a variety of factors most important of which are: (1) insufficient motivation as in the case of typesetters, whose greater output after introduction of a bonus system was described above; (2) insufficient integration of simpler habits into higher order habits like the letter and word habits of a typist or telegrapher; (3) a conflict between old habits and those being acquired, as when a person who has typed by the "hunt-and-peck system" has difficulty in acquiring the touch method because his older, less adequate mode of behavior, until it is suppressed, interferes with improvement.[20]

The best-known example of a plateau is that illustrated in Figure 89. Here we have a steady rise in letter and word curves for receiving up to what is apparently the physiological limit for these relatively simple habits. The receiving curve based upon connected discourse, on the other hand, shows a flattening out until the simpler habits have been perfected, then it rises. The rise is apparently due to an integration of simpler habits into higher order habits. The sending curve shows no plateau.



89

Learning Curves for Telegraph Sending and Receiving

The plateau is the flat place in the curve for receiving connected discourse as this curve nears the slowest main line rate. Flattened regions at the ends of the other curves may represent the physiological limit. They would be plateaus only if the curves subsequently rose. (After Bryan and Harter.)

TRANSFER

Learning one skill sometimes influences the acquisition of other skills. This influence may be positive, whereby the acquisition of one type of performance facilitates learning of another. The influence of earlier learning on later learning may, on the other hand, be negative, as when acquisition of one skill interferes with acquisition of another. In the first instance we have positive transfer of training, often referred to merely as "transfer of training" or "transfer of learning." In the second instance we have what is commonly called *habit interference.*

Bilateral transfer

One of the simplest examples of positive transfer is to be found in experiments showing improvement in performance with the left hand as a result of practice with the right hand. This is *bilateral transfer* or *cross-education.* Sometimes transfer is from one limb to another, as from hand to foot, or vice versa.

In the early studies of bilateral transfer, the skill used was mirror drawing, which utilized a device like that illustrated in Figure 90. The subject is required to trace the star-shaped pathway with a stylus, moving in a clockwise direction and attempting to avoid contact with the sides of the path. In the apparatus illustrated, each time the side is touched, an electrical contact is made and an electric counter records the error. The time taken to trace the star is also recorded. What makes the task a difficult one is that the subject does not see the path, except in a mirror, which, of course, produces a near-far reversal to which he must learn to adjust.

Experiments using this and other problems have shown that practice with the right hand improves performance with the left. Two equivalent groups of subjects are customarily used, a control and an experimental group. Both groups are given one trial with the left hand. One of these (the control group) does nothing further for the time being. The other (experimental group) is given a large number of trials, say fifty, with the right hand. After this training period is completed, both groups are given a further

trial with the left hand. The procedure just described may be presented in this fashion —

Control Group

Left hand (rest period) Left hand

Experimental Group

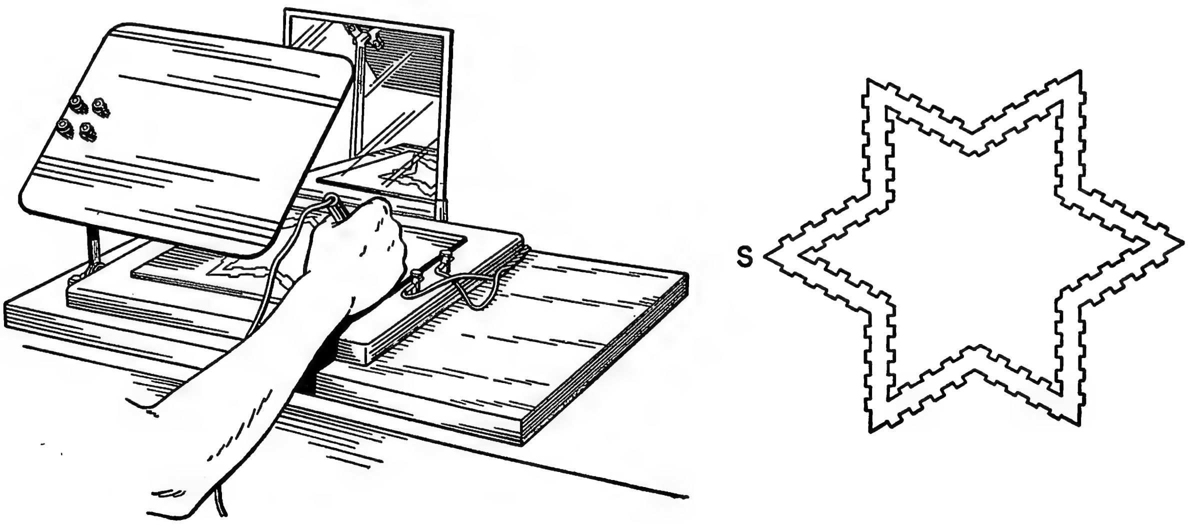
Left hand (Practice with right hand) Left hand

After this procedure has been followed through, the improvement in performance made by the control group is subtracted from the improvement made by the experimental group. This indicates the amount of improvement in the left hand through practice with the right. A control group is made necessary by the fact that the second trial with the left hand, because of what was learned in the first trial, would show some improvement, even if no training with the right hand occurred.

In one investigation of transfer in mirror drawing, the error scores of the control group dropped 55 per cent, without intervening practice with the right hand, while those for the experimental group dropped 76 per cent. Thus the per cent of transfer from right-hand practice to performance with the left hand was, from the standpoint of errors, about 21 per cent. Time scores for the control group dropped 46 per cent. Those for the experimental group dropped 82 per cent. Thus the transfer in terms of time was 36 per cent.[21]

TRANSFER FROM ONE ACTIVITY TO A SIMILAR ACTIVITY

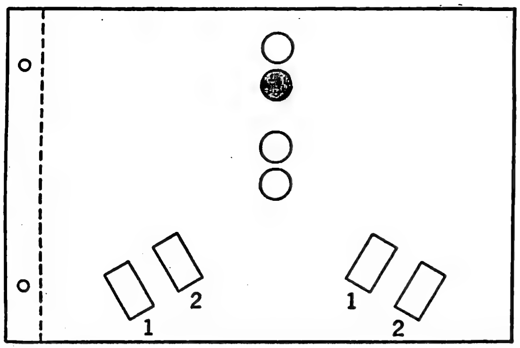
Learning one activity sometimes makes easier the learning of another activity. The learning of one maze pattern, for example, often facilitates learning of a different pattern in the same type of maze. Even practice on a paper-and-pencil task may transfer to a somewhat comparable motor task, as



90

Apparatus Used for Mirror Drawing

To the right is the pattern which is to be traced by the subject. Each entrance into one of the notches is an error. Sometimes a subject has great difficulty in getting out of a notch. He must do the opposite of what the mirror image seems to indicate, or be "stuck." (After Snoddy.)



91

A Paper-and-Pencil Task Simulating a Motor Skill

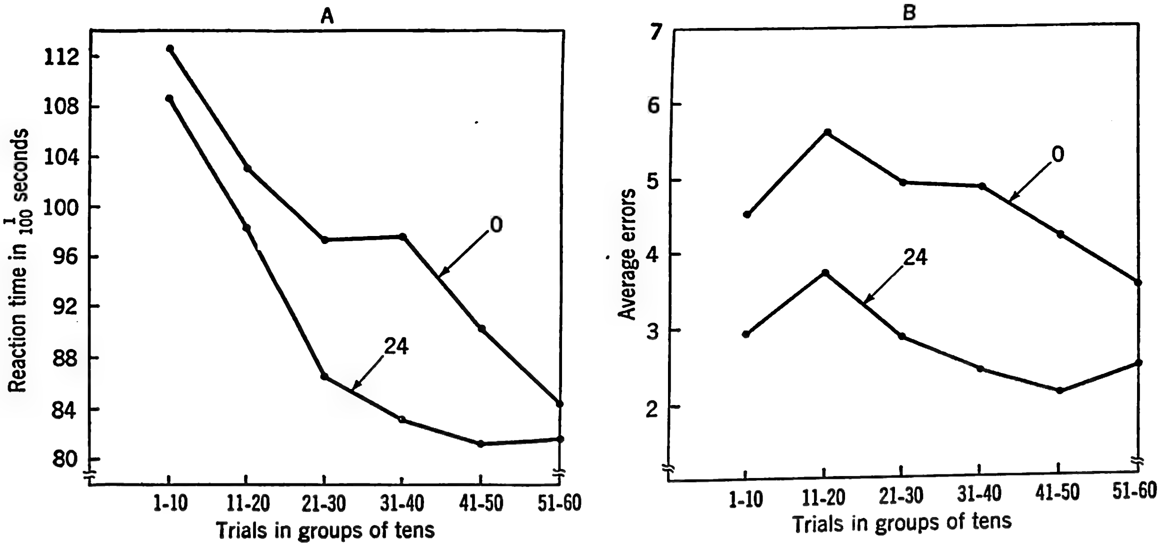
The circles on this page of the paper-and-pencil test represent lights in the panel of the apparatus used for the motor skill. On each page one circle is colored, for example, the second from the top as illustrated. This colored circle varies unpredictably from page to page. When it is colored, the top circle is always red, the next circle is always green, the next green, and the lowest red. On the sheet illustrated, the topmost green circle is colored. The rectangles on the paper-and-pencil test represent switches on the apparatus. The subject, in performing the paper-and-pencil test, is told that when a lower circle is colored he should make a cross in a rectangle on the left — in rectangle 1 if the color is red, and rectangle 2 if it is green. Conversely, when a higher circle is colored he marks a rectangle to the right — 1 if the circle is red, 2 if green. The subject does one page after another as quickly as possible until he has reached the final page. After the specified number of trials (pages) of this test, he goes to the apparatus. Here he responds to the same relationships, but to flashing colored lights, and by pressing a switch instead of making a cross. In these tests the response to each light is timed with a chronoscope, recording in hundredths of a second. Thus the measure of learning is in terms of reaction speed, although errors are also recorded. (From Gagné, R. M., and H. Foster, "Transfer to a Motor Skill from Practice on a Pictured Representation." J. Exper. Psychol., *1949, 39, p. 345.)*

illustrated in the experiment which we shall now discuss.

This experiment was carried out with 290 Navy enlisted men.[22] There were two similar and relatively complex sensorimotor tasks, one in a paper-and-pencil version and the other in an actual apparatus version. The general design of the experiment was as follows. One group (control) learned the apparatus task without practice on the paper-and-pencil version. Other comparable groups (experimental) learned the apparatus task after, respectively, 8, 16, 24 and 48 trials on the paper-and-pencil version, which is illustrated in Figure 91. The legend of this figure compares the pictorial with the apparatus situation. Results for the control group (0 trials) and one experimental group (24 trials) are illustrated in Figure 92. Figure 92, A shows learning in terms of reaction time; 92, B in terms of errors. The distance of the 24-curve below the 0-curve represents the degree of transfer. Positive transfer occurred in all groups. If practice on the pictorial task had not produced transfer, the curves would have coincided. Had there been negative transfer, the 0 curve would have been below the other.

Transfer from one type of activity to a different type

While there is, as we have seen, a great deal of transfer from right-hand performance to left-hand performance of the same activity, and from a pictorial to a motor task of the same pattern, there is negligible transfer from one type of activity to a quite different type. We might expect that having played tennis would facilitate the learning of badminton or some other similar skill, but we would not expect that it would facilitate learning baseball or some other dissimilar skill. It happens that research on transfer of motor skills has dealt almost entirely with similar activities and has generally shown a large amount of positive transfer. Research on transfer from one activity to a dissimilar activity has, for the most part, utilized verbal materials.



92 **Learning Curves for a Group Given No Paper-and-Pencil Training and a Group Given 24 Trials of Such Training**

The curves to the left were based upon reaction time in performing the motor task, and those to the right on errors. (The reaction time curve is plotted from data in Gagné and Foster, ibid., *p. 346. The error curve comes from p. 349.)*

Transfer in verbal learning

Results similar to those reported for transfer of skill in mirror drawing and maze performance have been reported for verbal skills. When comparable lists of nonsense syllables are learned one after the other, there is a gradual reduction in the trials required to learn successive lists. It is as if the subject is learning how to learn this type of material.[23] Somewhat similar results have been obtained with school children who memorized poems, digits, and other verbal materials. They learned similar materials with greater facility than did children not given the previous training. Where dissimilar materials were learned, however, transfer was negligible. Thus, children who memorized one kind of material usually did not memorize another kind any better than they would have without the previous training. Where improvement did occur, it was attributable to a carry-over of procedures, attitudes, or the like.

Three groups of children who were found to be equivalent in ability on the basis of memory tests were required to memorize poetry, tables, and the substance of prose selections. A fourth group, comparable with the others, did arithmetic problems requiring no memorizing. This training continued thirty minutes daily, four days per week, for three weeks. All four groups were then required to memorize nonsense syllables, prose selections, the data of maps, and various other materials. There was some transfer from learning poetry and tables to learning nonsense syllables, since children who previously learned poetry and tables gained from 66 to 85 more points in memorizing nonsense syllables than did those who had memorized the substance of prose selections, or who had merely done arithmetic problems. This improvement, however, probably came,

not from improved memory, but from application of techniques learned with one type of material to learning of another type. In some instances, as when the children went from nonsense syllables to the substance of prose, there was actually what appeared to be negative transfer. Those who had learned nonsense syllables apparently learned a technique which interfered with their memorizing of ideas involved in prose passages.[24]

Transfer of the nature indicated is usually short-lived. The subjects soon forget the techniques used, and their attitudes of concentration on the task weaken. After a lapse of time, the performances of control and experimental groups are equalized.

In an experiment on memory span for digits (the longest list of digits that can be recalled after a single reading), one group of children was given 78 days of practice, while a comparable group received no practice. Both groups had an initial span of 4.33 digits. The experimental group, as a result of the 78 days of practice, increased its average memory span to 6.40 digits. The control group, although given no practice after the initial test, increased its span to 5.06 digits, a gain of .73 as compared with 2.07 digits. But in a further test given four and one half months later, the difference between the experimental group and control groups was no longer evident. Further training given to both groups did not increase the span of the experimental group any more than it increased that of the control group. It was concluded that "the improvement brought about by training in this case is due to subtle techniques rather than to increased fundamental capacities." [25]

Bases of transfer

Where transfer occurs, either in motor or verbal learning, it comes from (1) *similarity of contents,* (2) *similarity of techniques,* (3) *similarity of principles,* or (4) *a combination of these.*

Similarity of contents

Parts of old habits may be "run off" as a response to new situations, perhaps with minor modifications. Thus, after learning items T S Q N A F P L J Z it is easy to learn T S Q N A F L J R because most of the items are learned already. A person familiar with several card games will learn the rules of another readily since many of the new rules are like those he already knows, i.e., a Queen takes a Jack; there are only four Aces in the deck, and so on. After one has learned to drive a car, he soon masters the controls of another. The brake is still under the right foot, a clockwise movement of the wheel steers the car to the right. In school subjects one also finds similarity of contents. Indeed, almost everything we learn in school is conveyed to us through words and other symbols learned earlier. Without this "common content," how could we hope to learn history, biology, physics, and other subjects? There is transfer from mathematical skills to mechanical engineering skills, because both involve the same symbols and symbolic relations. Transfer from one language to another occurs if the symbols and grammatical construction are alike. There is very high transfer from Spanish to Portuguese because of this similarity; and there is a certain amount of transfer from English to French because many words are similar.

Techniques. In an experiment on bilateral transfer, the subjects were required to toss a ball into the air and catch it in a cup to which it was attached by a long string. While practicing with the right hand, they often said, "I've got to get that cup a little lower so that the ball won't bounce out"; "I must toss the ball higher before trying to catch it"; or, "It's better to watch the cup than the ball." [26] When they were called on to take their trials with the left hand, these subjects used the same methods that they had figured out when practicing with the right hand. Some of their transfer, therefore,

depended upon a carry-over of techniques.

Relevant in this connection also is what we have already said about learning how to learn. There are courses in how to study which aim to teach the student how to organize his learning so as to make him maximally efficient. Any transfer that comes from such courses is a transfer of study techniques.

Transfer in terms of techniques also occurs if, having learned the scientific approach to problems in one subject, the student applies scientific procedures to problems in other fields. Likewise, if the student takes a course in formal logic and thereafter thinks more logically, or tests his thinking in terms of logic, the procedures of formal logic have been transferred. Occasionally, a student who has learned in mathematics to formulate a problem by letting x equal this, y that, and so on, applies the same type of formulation to comparable problems in everyday life.

A word of caution is, however, in order. Having taken a course in how to study, in scientific method, in logic, in mathematics, or any other subject, does not guarantee that transfer will occur. The teacher with his eye on transfer will do well to give practice exercises in which transfer is called for. In other words, he will teach how to transfer the methods to practical situations. Transfer, even though possible, does not take place automatically.

Some instances of insight may involve application of techniques. Suppose, for example, that a chimpanzee has, in the jungle, learned to reach otherwise inaccessible objects by swinging toward them on a vine. Now in the psychological laboratory, he is confronted with an apparently inaccessible banana. A rope, however, is hanging nearby. If the animal sees the similarity between the rope and the vine, or between his jungle method and the one now possible, he may solve the problem immediately.

Principles. Transfer of principles is not always clearly different from transfer of techniques, because the use of a technique may involve the application of principles.

An experiment which clearly involves transfer of principles is illustrated by the following: Children learned a problem in which one of several doors containing figures, and above which figures appeared, was to be opened in order to get a hidden toy. The principle which the children were to learn by their trial-and-error activities was this: "The correct door is always the one whose figure matches the one above it"; or, "none of the wrong doors have figures which match those above." After having learned this problem with figures, many children learned, without any further training, new problems in which colors alone were used. Having learned the principle with figures, they applied it to the color problem. Transfer was 100 per cent.[27] The transfer found in the paper-and-pencil and motor skill experiment (pp. 157–159) could be regarded as transfer in terms of principles, for the problem was partly one of responding to fixed relations between lights and switches.

A study of puzzle solving in human adults showed that, when subjects were taught the principle involved in solution of one problem, they solved, without any error, new puzzles which involved the same principle. Those who did not learn the principles involved failed to show much transfer.[28]

In one of the best-known experiments on transfer of principles, a group of boys was given instruction in principles of refraction, while another comparable group received no such instruction. Both groups were then called upon to hit an underwater target with darts. This they accomplished with approximately equal success. But when the target was shifted to a new position, the boys with a knowledge of the principles of refraction made a much more rapid readjustment than did those with no knowledge of these principles. The investigator came to the conclusion that generalization, or application of

principles to new situations involving the same principles, had occurred.[29]

Formal discipline

Studies of transfer have failed to support the contention, once quite prevalent, that training in certain subjects, like Latin and mathematics, serves to strengthen particular psychological functions. This doctrine, known as that of "formal discipline," has often been used to justify inclusion in the curriculum of studies which, although having no apparent practical value for certain students, are said to be useful in "improving memory," in "improving judgment," in "strengthening the scientific intellect," or in "giving elasticity to mental functions." The evidence from experimental investigations shows that transfer, where it occurs, is due to similarity of contents, of techniques, or of principles, not to development of particular psychological faculties or functions.[30]

When we say that a subject like Latin does not, any more than some other subject, increase one's intellectual capacities, we are not saying that studying it is a waste of time. It is exacting, and some people like to master exacting subjects, even when they see no practical outcomes. But it has also been maintained, apparently with justification, that the study of Latin improves one's English vocabulary and makes the many English words with Latin derivatives much more meaningful than they would otherwise be. Much of the Latin idiom is lost in translation, so that a student who wishes to feel and think with the Romans can do it better by reading Latin than by reading translations. The same is also true of Greek, as well as modern languages.

Habit interference

Many errors made in the early stages of learning are responses transferred, although inappropriately, from previous habits. Sometimes we experience great difficulty in eliminating these inappropriate responses. Since "carry over" from earlier training is usually a mixture of useful and useless, or interfering responses, we can see that whether transfer is positive or negative depends upon whether one's learning as a whole is aided or hindered by previous training.

When we come to thinking and reasoning (Chapter 9) we shall see that many of the errors, or false tries at solution, are carried over from what we have learned in other problem situations, but are inappropriate to meet the new situation. They send our thinking in the wrong "direction" and thus interfere with solution.

The most effective method of producing habit interference experimentally is to require the organism to learn the reverse of what it has previously learned. Thus, a rat that has learned to respond positively to a white area and to avoid a black area is now required to learn to respond positively to the black area and avoid the white; a rat that has been turning to the right in a T-shaped path is now required to turn to the left; or a rat that has been finding food in the northernmost part of the maze is now trained in a maze having food in the southernmost part.[31]

Habit interference is often demonstrated in the laboratory by using an apparatus like that pictured in Figure 93. Subjects learn to sort cards into pigeonholes having the same symbols as the cards. After high speed and accuracy have been attained, the position of the symbols is changed. Thus, the card with a certain number on it goes into the upper right-hand hole during original learning, but into the lower left-hand hole during the transfer tests. Learning the new positions is easier for one who has not learned the former positions than it is for one who has learned them.

We see habit interference in everyday life. The person who has learned to drive a car with a left-hand drive has unusual diffi-

93 A Card-Sorting Apparatus Used to Study Learning and Habit Interference

culty in learning to drive one with a right-hand drive. Anybody who has habitually guided a sled with his feet experiences a certain amount of interference when he learns to guide a plane. Pushing the rudder bar with the right foot sends a sled to the left, but it sends a plane to the right. Sometimes, too, the pilot, when wishing to turn, will try to use the wheel rather than the rudder bar. Some flyers have found themselves in difficulty because their training plane differed in certain respects from the plane they were finally called upon to fly.

A recent accident was reported which occurred when a pilot, in attempting to correct for undershooting a field, pulled back on the throttle and pushed the stick forward, resulting in a nose dive into the ground. This incorrect pattern of adjustment was due to the fact that the pilot was flying a plane in which the controls were placed differently from those in the plane in which he was trained. He was used to advancing the throttle with his right hand and pulling back the stick with his left hand; and the "left-hand-back, right-hand-forward" habit pattern transferred itself automatically, to the pilot's astonishment and resulting distress.[32]

Habit interference in verbal activities also occurs at times. After the end of the year, you may continue for some time to write the previous year on your checks, and you may continue to write May after June has arrived. Likewise, after your telephone number, or that of a friend, has been changed, you may continue for a time to use the former number.

Negative transfer, like positive, occurs on the basis of similar content, techniques, or principles, but it involves interference rather than facilitation. The contents, techniques, or principles which make for negative transfer are opposed to those required by the new situation. This has been formulated along these lines: when we are called upon to make old responses to new situations, transfer may be positive. However, when we are required to make new responses to old situations, transfer may be negative.[33] Think of the pilot accustomed to reacting in one way with a sled, who failed to react correctly to the right-turn situation in his plane.

SUMMARY

Skill is proficiency. It may be predominantly motor or predominantly verbal, but motor skills in man are to some extent verbal, and verbal skills are partly motor. When we engage in an activity with the intention to remember, we are said to be memorizing. Basically, however, memorizing is probably no different from other learning. Animal learning is the clearest instance of motor acquisition uncomplicated by verbal elements.

Basic to learning of skills by any organism is differential response to aspects of the environment, as illustrated in discrimination experiments. Such perceptual responses and

observations result in information which may or may not be used in overt performance, its use depending upon conditions of motivation.

In studying the learning process, we disturb the organism's adjustment, then observe its success in achieving a readjustment. One way of disturbing adjustment is to place a maze, a discrimination apparatus, a puzzle box, or some other obstacle between an animal and satisfaction of some need, such as the need for food, water, or sexual activity. Increasing proficiency is indicated by a decrease in time, errors, or excess activity involved in overcoming the obstruction, or by an increase in correct responses. Trials required before the criterion of learning is attained also give a measure of learning ability.

Maze learning in rats and human subjects is characterized by trial-and-error activity which, in man, is known to be partly implicit. Human learning of stylus and raised finger mazes is no more efficient than learning of comparable maze patterns by rats. One reason is that man's superior reasoning processes cannot be exercised very greatly in such situations. Another reason is that the rat is usually better motivated than the human subject. The chief value of the maze in studying human learning is that the subjects are likely to "start from scratch."

In solution of detour problems, puzzle boxes and tool-using situations, human subjects are far superior to other animals. Whereas both animals and men solve such problems by an overt trial-and-error attack, man is more likely to solve them by implicit trial and error and by observation. While animals below man sometimes solve such problems by grasping significant relations (or using insight) and by copying the performances of others (or imitating), they are more likely to use overt trial and error. Even where animals do learn problems by using insight and by imitating others, man solves problems of much greater complexity than the animals can solve on these bases.

Our acquisition of complex skills is often facilitated by observation of skilled performance. This does not mean that we learn complex skills by imitation alone, but it means that observation of skilled performance short-circuits, as it were, some of the overt trial and error that occurs in learning. Such observation also gives insights that might not otherwise occur.

Verbal learning is that in which language processes predominate. These processes play an important role in human motor learning, including acquisition facilitated by actual or motion-picture demonstrations of skilled performances. Learning to speak is based partly on imitation or, more properly, attempts to imitate, and partly on trial-and-error activity. Memorizing of verbal material is investigated scientifically by use of nonsense syllables, which, like mazes, are novel, starting the learner "from scratch." Poems, narratives, words, and other symbols are often used in studies of memorizing. These, however, are not as useful as nonsense materials, because the subjects, when they come to the laboratory, already have a certain amount of familiarity with the items involved. Another type of verbal material much used in learning experiments is the substitution task, where one symbol must be substituted for another, as in decoding messages.

Both motor and verbal skills have different levels of complexity. We are often required to learn relatively simple habits and then to combine them into habits of increasing complexity. Typing, telegraphy, and many other activities of everyday life are habit hierarchies which are developed in this way. A noteworthy thing about habit hierarchies is that, as higher-order habits develop, the simpler habits tend to become more automatic, which means that we are decreasingly aware of their presence.

Learning curves give a graphic record of the progress of acquisition. They tend to

approach a level of no further improvement with practice — a level known as the physiological limit. This limit is sometimes set by the nature of the problem and sometimes by the nature of the individual. Sometimes there is a flat place in the curve, indicating zero improvement as a function of practice. If improvement subsequently occurs, this place is known as a plateau — otherwise it suggests that the physiological limit has been reached. The improvement following a plateau may come from increased motivation, an integration of lower-order habits, or an overcoming of interference from conflicting habits or techniques.

Transfer may be positive or negative. Positive transfer from one activity to another — either motor or verbal — often occurs. When it does occur, however, such transfer is attributable to similarity of contents, techniques, or principles, the individual finding that what he has learned in one situation applies to this, that the techniques formerly successful can be used here, or that a principle learned earlier applies to this new situation. Negative transfer, or habit interference, is frequently evident when we are called upon to make new responses to familiar situations.

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8 FOUNDATIONS OF LEARNING

Sensory Contributions to Learning • Learning and the Brain: Amount of cortical tissue; location of lost tissue; specific sensory habits • The Role of Motivation: Rewards in animal learning; rewards in human learning; punishment and reward; praise versus reproof; knowledge of results; rivalry and recognition; passive versus intentional learning • The Relative Economy of Different Learning Procedures: Distribution of effort; why is distributed learning economical ?; recitation; whole versus part learning • Theoretical Aspects of Learning: Hull's reinforcement theory; Tolman's theory; place versus response learning; the role of reinforcement; is there only one kind of learning ? • Summary

In our discussions of conditioned responses and skills we made no more than passing reference to sensory, neural and motivational contributions. The relative effectiveness of various learning procedures also received scant consideration. We avoided theoretical issues as much as possible. This chapter supplements our earlier discussions by considering the role of sensory processes in learning, the involvement of neural mechanisms, the influence of different kinds and degrees of motivation, the procedures which produce the most economical learning, and two outstanding theories of learning. These, like all other theories of learning, are concerned with the questions "What do we learn?" and "How do we learn?" The answers, as we shall see, are far from being established.

Scientific theories have at least three important functions. One of these is to highlight significant issues, another is to show how facts now available bear upon these issues, and the third is to show where, in order to settle an issue, gaps in our knowledge need to be filled out by further research. An adequate discussion of learning theory would require a large book devoted to theory alone. Therefore, all that we attempt in this chapter is to take one issue, show how two of the major theories of learning deal with it, and then give our own evaluation of these theoretical approaches.

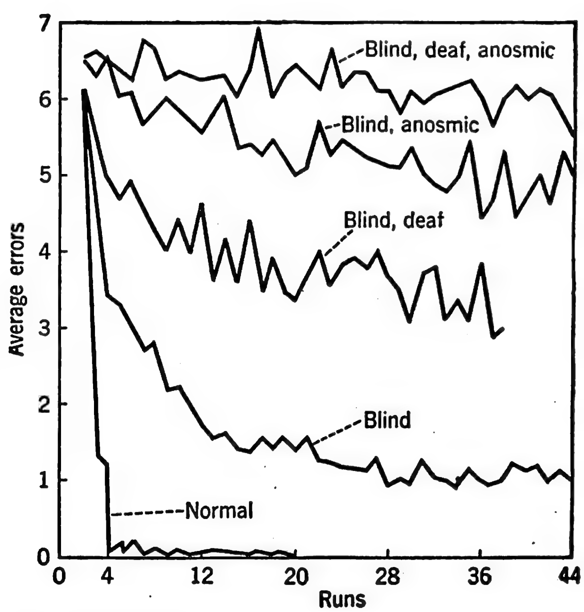
SENSORY CONTRIBUTIONS TO LEARNING

Learning requires differentiation of stimuli. This was dealt with in our discussion of discrimination learning. A problem of particular interest, however, is the relative importance of our various senses in habit formation. Verbal learning, as everyone knows, is practically non-existent in people who are born both blind and deaf, unless, as in the case of Helen Keller, the tactual sense is somehow used to represent what normally comes through sight and sound. Acquisition of motor habits does not show such dependence upon any particular avenues of stimulation.

The blind learn to find their way around on the basis of touch and hearing, but vision would of course greatly facilitate their learning. They also learn to avoid obstacles (see pp. 31–33) which to us are presented visually, but to them only through hearing. We learn to avoid these obstacles when blindfolded, also through the auditory sense.

Likewise the deaf person may learn to respond in situations where the rest of us use auditory cues. He learns to respond to them through his visual sense (lip reading) and his tactual sense (frequencies and intensities of vibration being sensed with the finger tips).[1]

The contributions of the senses to acquisition of a relatively simple motor skill is well illustrated by an experiment on white rats. In this experiment, large groups learned an elevated maze having five blind alleys. Some subjects learned the maze with all senses intact; some after being blinded; some after being both blinded and deafened; some after being both blinded and rendered anosmic (made insensitive to odors); and some after being blinded, deafened, and made anosmic. Before the operations which produced these sensory deprivations were performed, the groups were, in all important respects, equivalent. Thus, differences in their learning ability were attributable to sensory defects. Learning curves for these groups are reproduced in Figure 94. Normal rats deprived of the use of visual, auditory, and olfactory stimuli * were similarly handicapped.[2]



94 **Sensory Deprivation and Maze Learning**

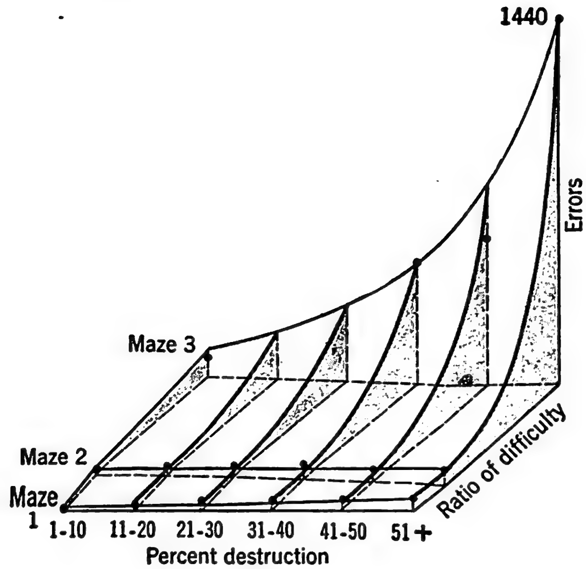
(From Honzik, C. H., "The Sensory Basis of Maze Learning in Rats," Comparative Psychology Monographs, *1936, vol. 13, No. 64, as arranged by Crafts,* et al., Recent Experiments in Psychology. *New York: McGraw-Hill, 1938, p. 147.)*

It is quite evident that learning is retarded to the degree that sensory stimulation is decreased or rendered ineffective as a source of cues. Blind, deaf, and anosmic rats (having only tactual and kinesthetic senses left to guide them) learn little, if anything. Experiments have shown that touch is of almost no use in learning this maze. Kinesthesis is important in the control of habits, once they are formed, but it is inadequate for the acquiring of new habits when vision and hearing are absent. These results, despite the fact that they were obtained with rats, and were confined to maze learning, suggest the general importance of vision and hearing in habit formation.

LEARNING AND THE BRAIN

The first clear evidence of learning comes in animals with nervous systems. Among these animals, those with the more complex nervous systems learn faster and acquire habits of greater complexity than those with simpler nervous systems. Development of the cerebral cortex, and especially of its association areas, is of especial significance for observational learning, the arousal of insight, and the development and utilization of language, which, as we have seen, plays an important role in the more complex forms of human learning. Growth of learning ability during the early years of childhood is related to increasing maturation of the cere-

* They were deprived of visual cues when run in darkness, of auditory and olfactory cues from outside of the maze when the whole maze was rotated to a different position for each trial, and of olfactory cues within the maze when, from one trial to another, the various units of the maze pathway were interchanged.



95

The Relation Between the Extent of Cerebral Lesions and Learning

Separation of the three curves indicates the relative difficulty of the three problems for normal animals. The abscissa shows the per cent of the cerebral cortex destroyed. The number of errors made in learning the respective problems is represented by the height (ordinate) of the graph. Maze 1 was the least and maze 3 the most complex. (From Lashley, K. S., Brain Mechanisms and Intelligence. *Chicago: University of Chicago Press, 1929, p. 74.)*

bral cortex. The decline of learning ability in old age, on the other hand, is probably due to deterioration of cortical tissues.

Experimental investigation of the importance, for learning, of the cerebral cortex as a whole, and of different parts of the cortex, has naturally had to be confined to animals. The most significant investigations in this field have been done by Lashley, with white rats.[3] His studies have indicated two important things about learning and the cortex: the relation between (1) learning and the *amount* of intact cortical tissue and (2) learning and the *location* of a specified amount of cortical tissue loss.

Amount of cortical tissue

The greater the amount of cortical tissue available to a rat, the more efficient its learning. This is illustrated in Figure 95. The graph is based upon learning of mazes by white rats deprived of different amounts of cortical tissue. Percentages of destruction are given at the bottom of the graph. Three mazes varying in difficulty were used, and the efficiency with which each was learned is indicated by the average number of errors.

Destruction of brain tissue up to 50 per cent did not greatly interfere with learning of the simplest maze. It interfered somewhat more with learning of the maze of slightly greater complexity. The same amount of destruction greatly interfered with learning of the complex maze.

The effect of increasing amounts of destruction became greater as the complexity of the maze increased. Observe, for instance, that destruction amounting to 41 to 50 per cent increased the number of errors from

maze 1 to maze 2 only slightly, but that it increased the number of errors from maze 2 to maze 3 approximately tenfold.

Location of lost tissue

As far as maze learning is concerned — and probably other similar sensory-motor learning — the location of a given amount of destruction is of little or no consequence. In other words, if you remove the same amount of tissue from the frontal, occipital, temporal, or parietal lobe, the effects on maze learning are approximately equivalent. It is true, of course, that removing tissue in the occipital lobe may destroy vision, while removing tissue in the temporal lobe may destroy hearing. But, with hearing gone, the animal still has vision and the rest of its senses to contribute to its learning of the maze. With vision gone, it has hearing and its other senses.

Lashley claims that cortical destruction in a sensory area does much more than eliminate the contribution of that sense. When the sense is eliminated peripherally (that is, without injuring the brain), the effects on learning are sometimes much smaller than when the corresponding sensory region of the brain is removed. Lashley attributes the greater loss from brain injury than from peripheral injury to a disturbance of the associative or integrative functions of the cerebral cortex. He believes that, so far as these associative functions are concerned, the different regions are about equally important. Others have taken issue with Lashley on this and related points, in answer to which he has obtained further results in support of his view.[4]

One should remember, of course, that Lashley's conclusions are based upon learning by rats. The different regions of a man's cortex, being much more complex than those of rats, might have different associative significance than the corresponding parts of a rat's brain. Some have criticized the generality of Lashley's conclusions on these grounds.

Lashley's view that the mass of intact brain tissue, rather than its location, is of greatest significance for learning, has been verified in experiments on problem boxes, again with rats.[5] Nothing at all comparable with these rat studies has yet been carried out on higher animals, thus the extent to which Lashley's "mass action" hypothesis is generally applicable is not known.

There is a large amount of information now available on the effects of human brain injuries, accidentally and surgically produced, but the effects cited concern intelligence rather than learning as such. The most extensive of these reports, dealing with over 200 cases, takes issue with the view that "mass action" is as evident in human as in rat learning. The tests used in this study as measures of "biological intelligence" call for perceptual and intellectual responses rather than motor learning, but learning ability is assumed to play a role in the test results.

A statistical analysis of the findings showed no relation between the degree of impairment in test performance and the mass of brain tissue removed. This analysis also contradicted Lashley's results on other grounds, for injuries in the frontal lobes were found to produce much more impairment than injuries elsewhere in the brain. To quote the investigator: "Biological intelligence . . . a basic function of the brain and . . . essential for many forms of adaptive behavior of the human organism . . . is represented throughout the cerebral cortex . . . with its maximal representation occurring in the cortex of the frontal lobes."[6]

If human learning were confined to the simpler processes involved in maze and puzzle-box learning, Lashley's conclusions concerning "mass action" might well be applicable. But processes like observation, insight, verbalization and reasoning play a major role in human learning, as they do in performing tests of intelligence at the human

level. It is not surprising, therefore, that the frontal lobes have been found to have greater significance in human test performances than the mere quantity of intact tissue, irrespective of location. Learning by rats and monkeys, in situations where recall of past experience and use of reasoning is required (pp. 68–69), likewise seems more dependent upon the frontal lobes than on other areas of the cerebrum.

Specific sensory habits

In the case of specific sensory habits, as in discriminating between sounds or figures or odors, Lashley and others have shown specialized sensory areas of the brain to be peculiarly important. Visual pattern discrimination in the rat fails to appear if the visual areas of the cortex are removed. But acquisition of this habit is not affected (except in trials to learn, errors before mastery, or the like) if some non-visual part of the brain is destroyed. As far as specific sensory habits are concerned, then, different parts of the brain are not equally important, even in the rat. This finding applies quite clearly to men as well as to rats. The same situation holds in the case of motor function *per se.* In other words, the specialized motor areas are more important for control of actions than are other regions.

THE ROLE OF MOTIVATION

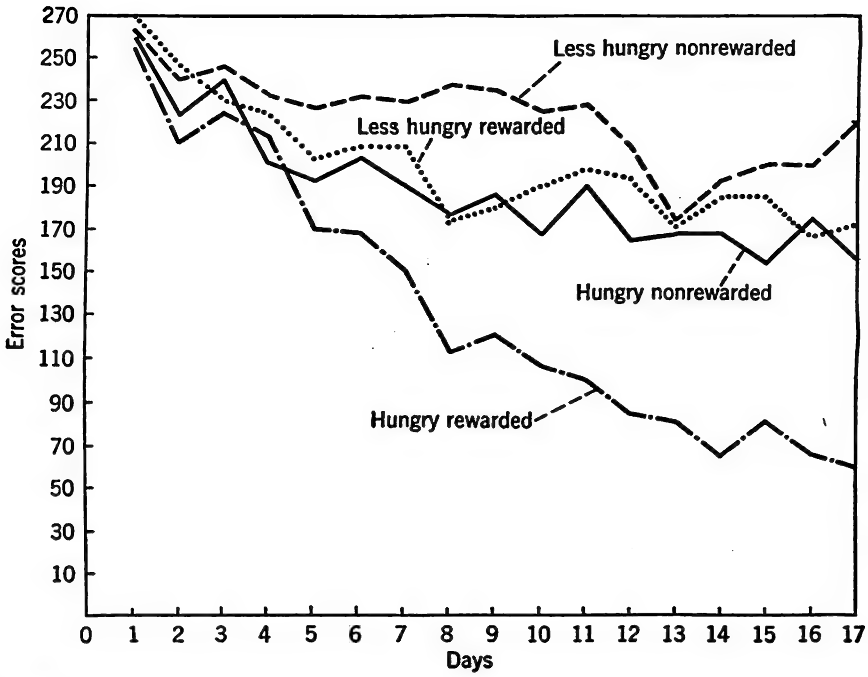
In research on learning, it is almost axiomatic that adequate motivation must be provided. The hungry animal must receive food; the thirsty one, water; or the punished or confined animal must escape. Such reinforcement is obviously necessary where learning of skills is concerned. It is not so obviously an aspect of conditioning, but even here, as we pointed out earlier, reinforcement in some shape or form seems necessary. Instrumental conditioning provides reinforcement in that the organism's response brings food or escape. But we called attention to the fact that classical conditioning also involves reinforcement to the degree that the conditioned response relieves tension, or expectation.*

In the examples which follow there is emphasis more on the relative effectiveness of different kinds and degrees of reinforcement than on the question of whether reinforcement is essential to learning.

Rewards in animal learning

Learning of hungry rats which found food at the end of the maze was compared, in one investigation, with the learning of rats which were hungry and found no food, and with the learning of rats which were not hungry and found food. As illustrated in Figure 96, the hungry rewarded group showed normal progress toward mastery of the maze habit, while the other groups exhibited little progress. The slight learning by hungry nonrewarded and less-hungry rewarded rats may be attributed to the incentive value of escape from the maze. Time scores for these groups actually increased during the course of the experiment, while those for the hungry rewarded group decreased in the normal manner.

* A strong claim for non-reinforced learning comes from experiments on so-called "sensory preconditioning" where the mere pairing of two stimuli brings about an association. After repeated pairing of the two stimuli, one is subsequently used as a conditioned stimulus. Finally, the stimulus paired with it earlier, but never used in the conditioning situation, is shown to be effective in arousing the conditioned response.[7] But even here, one could argue that whenever one stimulus repeatedly follows another after a specified interval, the coming of the second stimulus provides reinforcement for the tension or "expectation" induced by onset of the first. The equivalence of the "sensory-preconditioned" and the conditioned stimuli could thus be envisaged in terms of reinforcement. One difficulty with such an interpretation, however, is that the "expectation" of the second stimulus is itself a product of learning — but reinforced by what? The question of reinforcement, as it applies to so-called "latent learning" and to "incidental learning," is considered elsewhere (pp. 190–191).



96

The Effect of a Food Reward on Maze Learning in Rats

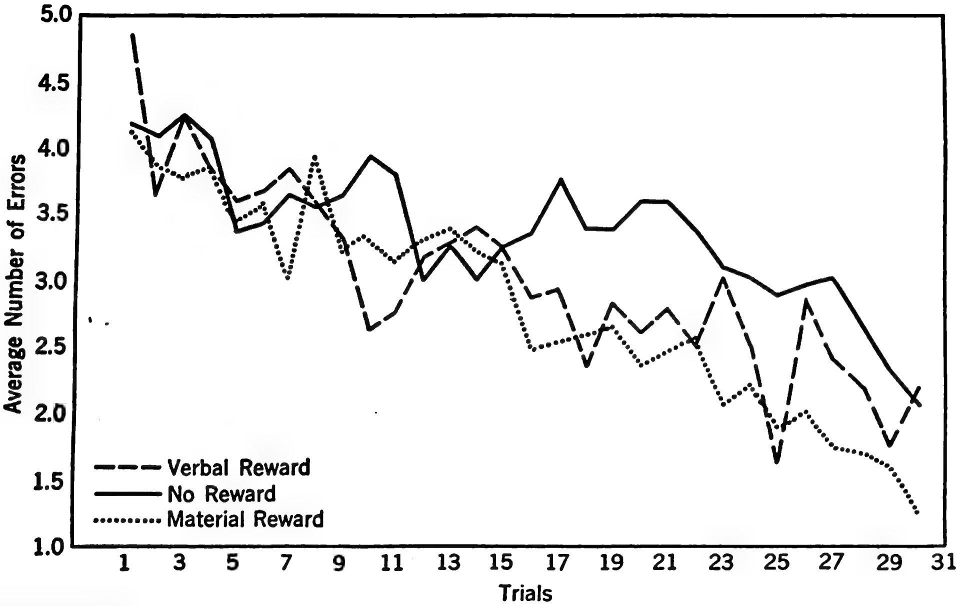
(From Tolman, E. C., and Honzik, C. H., "Degrees of Hunger, Reward and Non-Reward, and Maze Learning in Rats," University of California Publications in Psychology, *1930, vol. 4, p. 246.)*

The introduction of a reward after rats have made a number of non-rewarded trials in a maze results in a sudden improvement.[8] Withdrawal of a reward,[9] or change to a less preferred reward,[10] after performance has reached a high level of efficiency, leads to less efficient maze running.

Rewards in human learning

Monetary rewards and praise are effective in human learning. This can be illustrated by an experiment on the learning of an elevated finger maze by sixty boys. Three groups having equivalent chronological and mental age were used. Members of the first group received no reward other than that which might come from satisfaction in learning the maze; members of the second group received a material reward (a penny) at the end of each trial; and members of the third group received a verbal reward, such as "Good," "Very good," or "Let me see if you can make even fewer mistakes this time." The curves in Figure 97 show that the no-reward group learned slowly, the verbal-reward group somewhat faster, and the material-reward group fastest. The average number of errors in the last five trials was: no reward, 2.6; verbal reward, 2.3; and material reward, 1.7. Statistical analysis shows that, although these differences are small, the chances are almost 100 in 100 that they result from different motivation, and not from chance factors.

In a further experiment, utilizing the same maze but different boys, a quarter was given for every trial without error. Although not many perfect performances occurred, and



97

The Effect of Different Rewards on Human Maze Learning

Although there is much overlapping in these curves, the retardation of the no-reward group becomes quite evident between the 15th and the 29th trials. (After Abel, L. B., "The Effects of Shift in Motivation upon the Learning of a Sensori-Motor Task." Archives of Psychology, *1936, No. 205.)*

few quarters were thus received, this condition led to the fastest learning of all.[11]

Punishment and reward

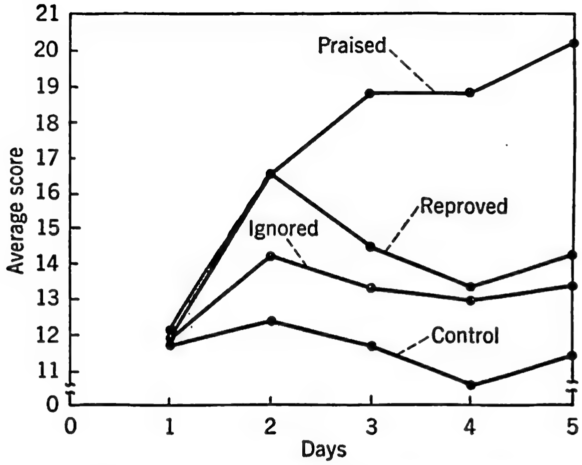
Numerous experiments on learning in rats and human subjects have compared the effect of punishment and reward, the punishment usually being a mild electric shock. In most of these studies, involving a variety of learning situations, shock for errors has been more effective, in combination with reward, than reward alone.[12] However, the effect of punishment is not clearly indicated. If punishment is given for incorrect responses, it leads to more rapid elimination of these responses than occurs without it. However, under certain conditions, punishment for correct responses, which are also rewarded, leads to more rapid fixation than occurs without it.[13]

Punishment, or the "annoyance" produced by it, tends to make the learner more cautious and more sensitive to the stimuli associated with a response, whether correct or incorrect. It develops attitudes of anticipation like those already considered in the discussion of conditioning.

Annoyers do not act on learning in general by weakening whatever connection they follow. If they do anything in learning, they do it indirectly, by informing the learner that such and such a response in such and such a situation brings distress, or by making the learner feel fear of a certain object, or by making him jump back from a certain place, or by some other definite and specific change which they produce in him.[14]

Praise versus reproof

What is the relative effectiveness of prais-



98 **The Effect of Different Motivating Conditions on Solution of Arithmetic Problems**

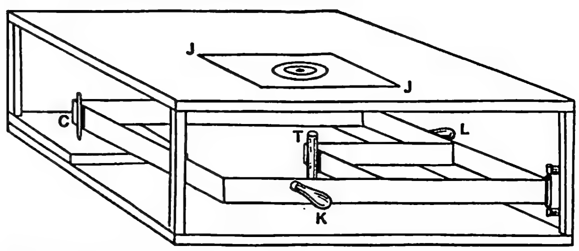
Note that the scores of all four groups were initially equivalent. (Drawn from data in Hurlock, E. B., "The Evaluation of Certain Incentives Used in School Work." J. Educ. Psychol., *1925, vol. 16, p. 149.)*

ing good performances and reproving poor ones? One of the best studies on this question was done with 106 fourth- and sixth-grade girls. Four groups, matched in initial ability, in age, and in sex, were used. The task was that of solving as many as possible of thirty arithmetic problems in a time limit of fifteen minutes. Five comparable groups of problems were used, one on each of five trials, given one day apart. The reproved group, regardless of how well it did, was asked to come to the front after each day's work and face the class. It was then "bawled-out" for its mistakes, careless work, and failure to improve. This group actually had no knowledge of how many problems it had solved correctly in the time limit. The praised group, regardless of how well or how badly it performed, faced the class each day and was complimented on its fine performance. The ignored group, while it heard the praise and reproof administered to the other groups, was not referred to during these periods. A control group, working in a separate room, was neither praised nor reproved. It did not observe the treatment of the other groups, nor was it given any suggestion concerning the status of its own performance.[15]

The results of this experiment are graphically presented in Figure 98. Here we see that the average score of all four groups was initially the same — about twelve problems solved correctly. On the second day, both the praised and reproved group gave a comparable performance, solving an average of slightly over sixteen problems. From this point on, however, the praised group improved and the reproved group grew worse. Neither the ignored nor the control group showed any consistent improvement.

Knowledge of results

Motor skills are not acquired unless the



99 **Two-Hand Co-ordination Apparatus**

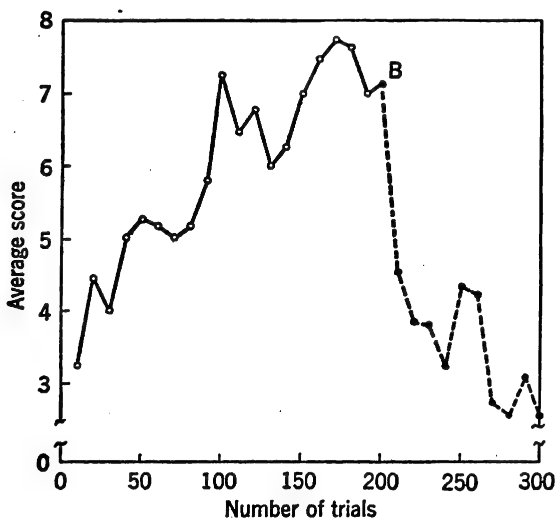
The subject was instructed to move handles K *and* L *in such a manner as to throw a spot of light from the torch* T *upon the bull's-eye of the target,* J, J. *Too small a movement of* K *caused the spot to move too far up on the target, while too small a movement of* L *caused the spot to move too far to the left. The performance was registered on a sheet of paper at* C. *A score of 10 was given for a bull's-eye, 9 for the next ring-out, and so on. The outermost ring scored 1 and a miss scored 0. The subject was required to move both hands just once at each trial. In other words, he was not allowed to explore until he located the target. (From Elwell, J. L., and G. C. Grindley, "The Effect of Knowledge of Results on Learning and Performance."* British J. Psychol., *1938, vol. 29, p. 41.)*

subject has some knowledge of results. This is neatly illustrated by an experiment in which the apparatus of Figure 99 was used. By proper manipulation of both handles at once, the subject could move the spot of light onto the bull's-eye. He was given a score based upon how close he came to the bull's-eye. After preliminary practice, two groups were trained, one with the light off so that no knowledge of accuracy would be possible, and the other with the light on so that accuracy in hitting the target would be known. Five subjects working without knowledge of results failed to show any improvement. They became exceedingly "bored" with the whole procedure.

The learning curve for a group of ten women students is shown in Figure 100 preceding the point *B*. At *B* and thereafter, the light was turned off so that there would be no further knowledge of results. The rapid drop in performance which followed this point may be attributed to the loss of motivation which came with withdrawal of knowledge of results, not from forgetting what had been learned up to this point. Similar results were obtained with another group of ten students. The investigators conclude that:

> Knowledge of results leads to improvement in performance: (*a*) by causing a tendency to repeat actions which have been successful; (*b*) by what may be called a "directive effect," i.e., by causing a tendency to correct, in the appropriate direction, any unsuccessful action; and (*c*) by setting up a conscious attitude or mood which is conducive to accurate performance. Removal of knowledge of results produces, on the other hand, an attitude which is not conducive to accurate performance.[16]

The need for knowledge of results, if learning is to proceed normally, is shown also by several other experiments. We have already referred to records of flight performance from which learning curves were constructed. When pilots see these records, such a knowledge of results facilitates their learning. Experiments utilizing verbal material have also shown that a knowledge of results makes for more effective learning.[17]

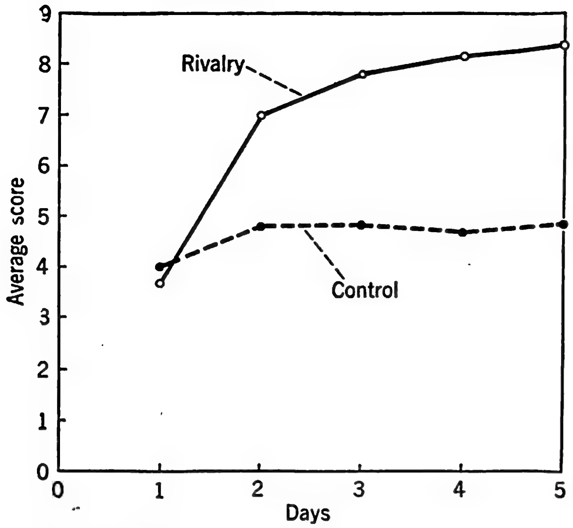


100 **Average Performance of Ten Women in the Two-Hand Co-ordination Test**

There was knowledge of results up to the 200th trial. From this point on, the light was turned off so that subjects could not tell whether they had hit the target. (After Elwell and Grindley, ibid., p. 45.)

Rivalry and recognition

Human beings are greatly stimulated to put forth effort when competing with others, and when they know that social recognition will come to those who achieve. This was demonstrated in a classroom research in which groups of children did addition problems in five consecutive daily sessions. Some groups did the problems under conditions where no rivalry and no recognition for achievement were involved. Comparable groups did the same problems, but under conditions involving intergroup competition. After each day's session, the children of the winning group held up their hands so that other children could see them. Not only this, but their names were placed on the black-



101 **The Effect of Group Rivalry and Social Recognition on the Learning Process in Grade IV**

(Drawn from data reported by Hurlock, E. B., "The Use of Group Rivalry as an Incentive." J. Abn. and Soc. Psychol., *1927, vol. 22, p. 285.)*

board. The curves in Figure 101 show that the rivalry and no-rivalry groups started with approximately the same average number of additions. After the experimental conditions had been introduced, however, the rivalry group improved and remained above the other in performance. The same general result held for accuracy and number of problems solved.[18]

It should be recognized, of course, that intense rivalry may have disruptive effects on performance and interfere with learning.

Passive versus intentional learning

While a certain amount of unintentional learning (but not necessarily unmotivated learning) occurs, the learning of verbal skills, like recitation of poems, narratives, and lists of words, seems to require motivation in the form of intention to learn. Psychological literature contains many examples of failure to learn because the intention to do so was absent.

I have read aloud for several years, three or four times a year, and five successive times on each occasion, the same list of twelve words which students in my class are required to memorize as I read them. Students usually reproduce the twelve words in the correct sequence after three or four readings. Nevertheless, I cannot at this time recall a single word in the list. Even after reading the list five times in succession under these conditions, I could not completely reproduce it. The reason students learn this list so readily is that they *intend* to do so. The reason that I do not learn it is that I have no intention of doing so. There is no reason why I should learn it.

How many times have you read a passage in a book, only to stop and realize that you are merely reading the words while thinking of something else, and that you are understanding absolutely nothing of what you read? All of us have had the same experience many times.

Failure to learn, when there is no intention to do so, is also illustrated in the case of skills that are not predominantly verbal.

Many times I have gone to a certain institution, riding in a student's car. Each time we have gone over the same route, yet I could not, no matter what the inducement, follow that route without help. The reason that I have not learned it is that, instead of finding it myself, or intending to learn it while traveling with someone else, I have taken a purely passive role.

Several experiments, in which subjects were mechanically guided through performances instead of initiating their own responses, have shown that complete learning of a skill does not occur on this basis alone. Guidance sometimes aids in the acquisition of a skill, but sometimes fails to have any effect.[19]

It should be clearly apparent from the preceding discussions that learning is inefficient, if not absent, unless motivation to learn is provided. We cannot at the present time,

however, say which kind of motivation or which incentives are most effective. Praise, for example, is better than blame, but is it better than a piece of candy, a certain amount of money, or physical punishment? This we cannot say, for the wide variety of possible incentives has not been investigated under comparable conditions. Moreover, the results reported are averages for groups. When we consider human individuals, it is clear from general observation that some are motivated more by blame than by praise, and some are motivated more by money than by either.

THE RELATIVE ECONOMY OF DIFFERENT LEARNING PROCEDURES

Assuming that the subject is well motivated, what are the best procedures to be followed in developing proficiency? Is it better, for example, to concentrate practice periods, or to distribute them with a shorter or longer interval between? Within a given practice period, is it better to give just one trial, or to give a number of trials? What is the most economical interval to introduce between practice periods — one hour, six hours, or a day? In memorizing verbal or motor skills, is it better to go over the material again and again, without a recitation or rehearsal, or is it better to introduce recitation or rehearsal periods at intervals during the original learning? If so, what proportion of the learning time should be given to reading, and what proportion to recitation? In learning a poem, a maze, or any other serial habit which may be broken up into parts, is it better to learn it a part at a time, or is it better to go over the whole thing from beginning to end at each trial? These are the chief questions with which discussions of economical learning are concerned. A great amount of research, involving animals and men, children and adults, and motor and verbal materials, has been concentrated on such questions.

Research shows, in general, that some sort of distribution tends to be better than massed learning, but it does not enable us to say what sort of distribution is best in every learning situation. Its value for a particular learning situation, not actually investigated experimentally, is to suggest discovery, in this situation, of the most appropriate distribution of effort. What applies to one situation (laboratory, classroom, or factory), or to one type of material (learning poems and learning to fly), might not apply to others.

Research shows, too, that recitation or rehearsal of what one is learning is desirable. But it again does not tell us what distribution of recitation and learning time is most economical for situations other than those investigated directly. We know the best distribution for learning certain nonsense materials and biographical passages, but we do not know what it would be, say, for learning French verbs.

Research shows, finally, that whole learning is sometimes more economical than learning by parts but that there are other situations in which learning by a combination of part and whole procedure is most effective.

With the limitations of such findings in mind, we are ready to consider some of the research on economy in learning.

Distribution of effort

Here we actually have two problems: (1) what is the optimal amount of work per practice period — i.e., between rest periods? One might study for 15 minutes, 30 minutes, or 60 minutes before taking a rest. (2) Given a certain work unit, what duration ol rest is most effective? If one is to study for 30 minutes at a time, for example, should he rest 5 minutes, 10 minutes, 15 minutes, or longer between each study period?

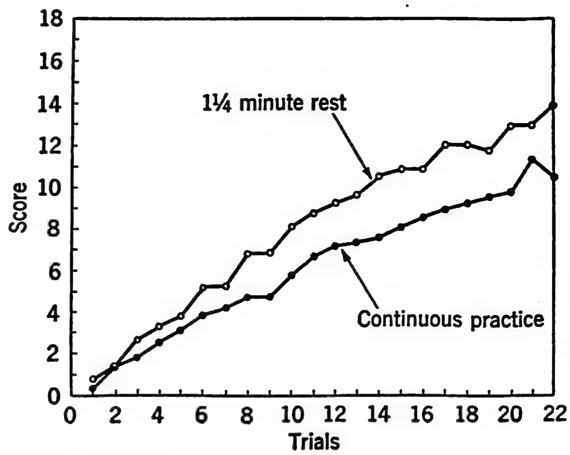
Variations in the unit amount of work and in the length of the rest period, singly and

together, both influence the progress of learning. However, the optimal work unit or rest interval, or the optimal combination of these, varies a great deal for different tasks, for different subjects, and for different degrees of motivation. The following references to three laboratory investigations suggest the design of experiments utilizing (1) different amounts of work, (2) different durations of rest, and (3) different combinations of work and rest.

Amount of work per period with the rest period constant. Three comparable groups of college students were given six practice periods of, respectively, one, two, and four minutes on a pursuitmeter (p. 153). The rest interval in each case was three minutes. Comparisons were based on the per cent of time that the stylus was on the target. In all six trials the percentages for the two-minute group were higher than those for the other groups. This was true despite the fact that the two-minute group had a total of only twelve minutes of practice as compared with twenty-four minutes for the four-minute group.[20]

Constant amount of work with variation in the duration of rest. In a study on the influence of different durations of rest, each work unit (trial) comprised 20 exposures of a list of 18 nonsense syllables. The group with massed learning had continuous practice for 22 trials, but other groups were given a rest of, respectively, 8, 3½, 2 and 1¼ minutes between trials. Figure 102 represents the learning of these 18 nonsense syllables by the group with no rest and the group with a 1¼-minute rest. The longer rest periods were all more economical than zero rest, but not more so than this shortest rest period.[21]

Work and rest periods independently varied in learning the same task. This type of experiment is illustrated by a study which required students to pick up, turn over, and replace small cylindrical blocks in four rows of 15 holes each, as shown in Figure 103, A.



102 **Learning as Influenced by the Rest Interval**

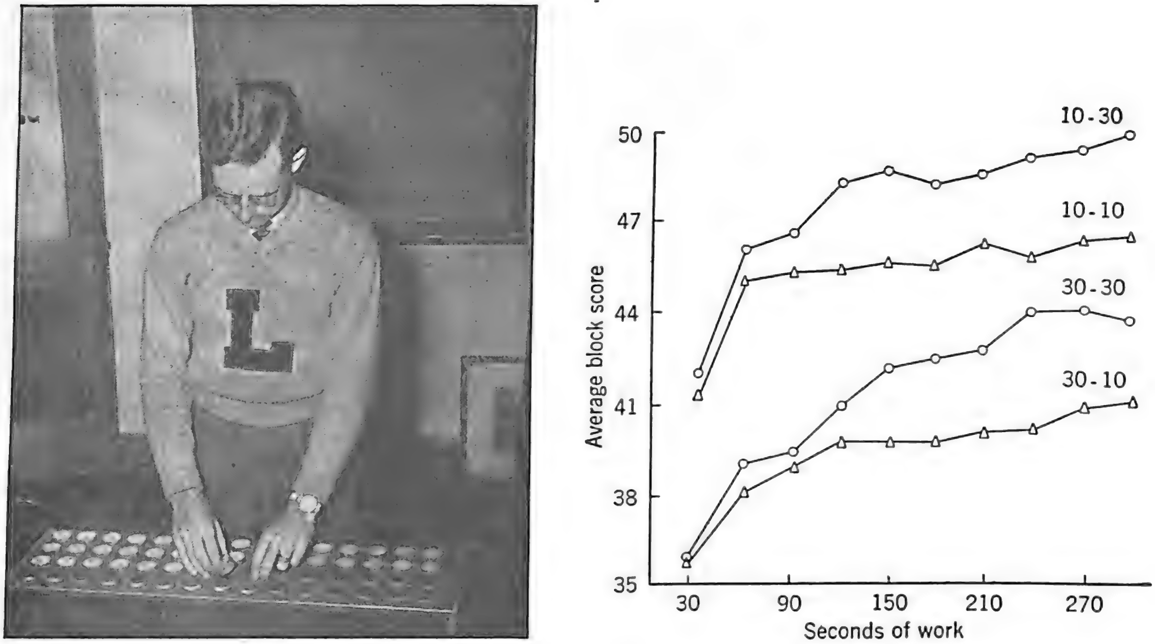
Observe that the group with continuous practice did not, after the second trial, reach the performance level of the group given 1¼ minute rest intervals. The score was the number of syllables correctly anticipated (recalled without prompting). With the anticipation method, one syllable is given and the subject tries to recall the next. If, within a fixed period, he fails to do so, the syllable is given and he attempts to recall (anticipate) the next, and so on until the last syllable is reached. (From Wright, S. T. H., and D. W. Taylor, "Distributed Practice in Verbal Learning and the Maturation Hypothesis." J. Exper. Psychol., *1949, 39, p. 529.)*

Each subject's score was the number of blocks that he turned over. The design of the experiment is shown in Table 3. Observe that, with work constant at 10 seconds, rest periods of 10 and 30 seconds were used. With work constant at 30 seconds, 10- and 30-second rest periods were again used. This experimental design enabled the experimenter

TABLE 3. DESIGN OF THE EXPERIMENT

(From Kimble and Bilodeau.)

Group	*Work period*	*Rest period*	*Number of subjects*
1	10 sec.	10 sec.	24
2	10 sec.	30 sec.	24
3	30 sec.	10 sec.	24
4	30 sec.	30 sec.	24



A B

103

Learning as Influenced by the Amount of Work and the Duration of Rest Periods

The work studied in this experiment is illustrated in A, *the Minnesota Rate-of-Manipulation Test. The curves in* B *summarize the results of the study. 10–30 means a 10-second work period with a 30-second rest between periods. This combination gave the highest scores (average number of blocks turned over and replaced). Note that both 10-second work groups reached a higher level of performance than either of the 30-second work groups. With both work units, the 30-second rest period yielded the higher scores. (Photo from Prothro and Teska,* Psychology. *Boston: Ginn, 1950, p. 511. Curves from Kimble, G. A., and E. A. Bilodeau, "Work and Rest as Variables in Cyclical Motor Learning."* J. Exper. Psychol., *1949, 39, p. 153.)*

to discover which is a more important determiner of efficiency in performing the task, the amount of work or the duration of rest. It also indicated which combination of work and rest brings the most efficient learning. The results are summarized in Figure 103, B. Note that the 10-second work period, with either a 10- or a 30-second rest, yielded the higher average scores. We can thus say that a 10-second work period, for this task, is more economical than the 30-second work period. Also, the 10-second work period was superior with a rest period of either length. Thus we can also say that the amount of work is a more significant variable than the rest period. But the efficiency of performance *does* also vary with the rest period. Observe that, with either work unit, the 30-second rest is more economical than the 10-second rest. The most economical combination of work and rest is a 10-second work period and a 30-second rest.[22]

The most effective work unit for any task, as well as the most effective interval of rest, must, as we have already said, be determined for the particular task and subjects concerned. If I find that a 30-minute study

period separated by an interval of 15 minutes is best for me, I cannot assume that it will be best for you. Nevertheless I am justified in assuming that some sort of distribution will be better than none.

Sometimes a practical situation arises which, despite its poor economy in other respects, may make massed practice more desirable than distributed practice. Suppose, for example, that skilled workers could be turned out with fewer lessons if their lessons were shortened, or came after a longer interval, but that you needed skilled workers in a hurry. Let us say that a certain skill is acquired in 50 standard lessons when lessons are given 5 times daily, and in only 30 when they are given one day apart. Distributed learning saves 20 lessons. With massed practice, however, a worker acquires the skill in 10 days; with distributed learning he acquires it in 30 days. Economy in time to get skilled workers, therefore, might dictate massed learning even though workers would need 20 trials in addition to those required if learning were distributed over a longer period.

There is another practical consideration which might make a certain degree of massed learning better than distributed learning. Some individuals take a long time to "get down to business" in studying or other kinds of learning. These would waste a large proportion of each interval before accomplishing anything; hence, might accomplish more if they worked a longer period at a time.

Why is distributed learning economical?

There are various reasons why distributed learning is generally more economical than massed learning. These reasons will be considered with respect to (1) the work unit, and (2) the rest period.

The length of the work unit. If this is prolonged, fatigue may set in, thus offsetting the effectiveness of one's efforts. Everyone has experienced the "lost motion" of trying to study, or to accomplish anything else, while fatigued. A short work unit, moreover, usually produces better motivation than a long one. Extra effort is induced, as in a short sprint. But a large work unit induces us to save ourselves for the "long pull" ahead.

The rest period. A rest period, like a short work unit, reduces fatigue and leads to improved motivation, but it has additional advantages. Once we stop work there is apparently a perseveration of neural processes aroused by our activities. Such perseveration perhaps underlies the "running of a tune through the head." According to one theory, perseveration "consolidates" what has been learned. A rest period is thus assumed to be advantageous because intense external stimulation ceases and allows internal consolidation to occur.[23]

There is evidence supporting the view that organisms resist (are refractory to) early repetition of an act. This may be a further reason for the relative ineffectiveness of massed learning. Rest periods obviously reduce the necessity for such repetition.[24]

One other factor may be of even greater importance than those already mentioned as favoring rest periods in learning. This is the tendency for incorrect associations (errors) to be forgotten faster than correct ones. We would expect such differential forgetting, the reason being that erroneous responses receive no positive reinforcement. But how does this bear upon the effectiveness of rest periods? The answer is that without a rest, forgetting cannot so readily occur. With an interval between trials, forgetting occurs, with the incorrect associations being weakened much faster than the correct ones. If the incorrect weaken faster than the correct associations, there is of course a relative advantage to the latter when practice is resumed after the interval.[25]

We see, then, that fatigue, poor motivation, restricted perseveration, resistance to early repetition of an act, and hindrance to

differential forgetting of correct and erroneous responses may all contribute to the lessened efficiency of massed as compared with distributed learning.

Recitation

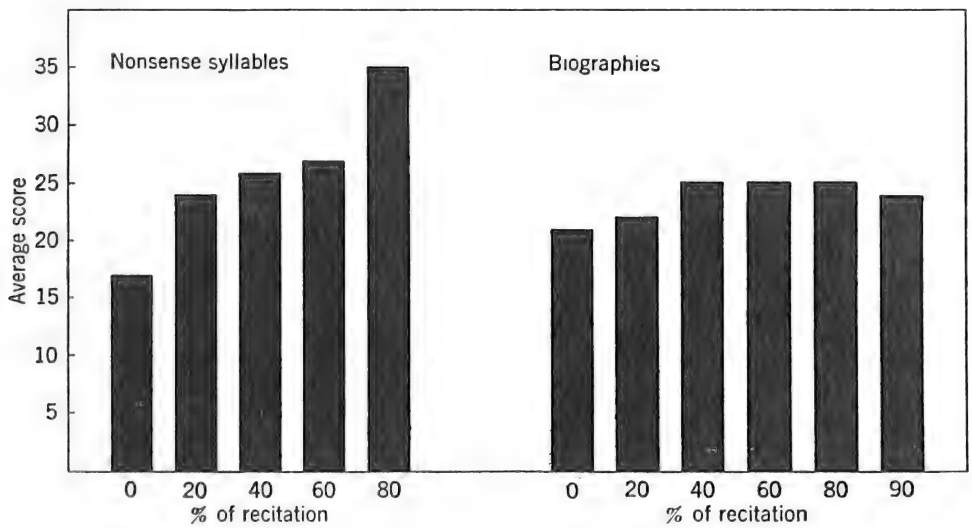
The value of recitation versus mere reading has been investigated for memorizing a variety of verbal materials. The best-known study is that in which large groups of children from several grades memorized nonsense syllables and brief biographies.[26]

Some children put 100 per cent of their time into reading the material. A comparable group put 80 per cent of its time into reading, and 20 per cent into reciting what it had read. Another group, comparable with the others, put 60 per cent of its time into reading and 40 per cent into reciting, and so on, down to the group which put only 20 per cent of the time into reading and 80 per cent into reciting.

Typical results in memorizing lists of nonsense syllables are presented graphically in Figure 104. It is apparent that the larger the percentage of recitation, up to the limit indicated, the greater the efficiency of learning. In this instance the largest amount of recitation was 80 per cent.

When biographies were to be learned, the maximum amount of recitation was increased to 90 per cent. In general, as shown in Figure 104, recitation was not as advantageous for learning of this meaningful material as for learning of nonsense syllables. Nevertheless, each percentage of recitation yielded better results than no recitation at all. These results were obtained with the eighth grade, but experiments with other grades yielded similar results.

In a more recent investigation with fifth- and sixth-grade children memorizing nonsense syllables, arithmetical facts, a difficult English vocabulary, and spelling, almost all the various distributions of reading and recitation used were better than reading without any recitation. The results of both studies



104

The Relative Efficacy of Different Proportions of Reading and Recitation in Memorizing

Efficiency of memorizing is seen to increase with increasing proportions of recitations, up to 80 per cent for nonsense syllables and 40 per cent for biographical material. All percentages of recitation are more economical than none at all. (Drawn from data reported by Gates.)

make it clear that recitation contributes to efficiency in memorizing.[27]

Why recitation should be more efficient than mere reading is fairly clear. In the first place, reading with the knowledge that one must soon recite what he is reading is conducive to good motivation — to what some have called "the will to learn." We have seen that intentional learning is much more efficient than incidental learning. In the second place, a recitation tells us how well we are progressing. It gives a better knowledge of results than could occur from passive reading. Every time we reproduce something read there is a reward element introduced, and every time we fail to reproduce an item there is an effect somewhat comparable with punishment for incorrect responses. In the third place, one must eventually recite the material — so the person who recites is practicing the sort of reproduction he aims to achieve.

Whole versus part learning

Perhaps the least generally applicable of the learning principles mentioned is that which refers to learning by parts as compared with learning by wholes. In part learning the individual concentrates on one portion of the material, or on one aspect of a skill, at a time. He masters the parts separately and then combines the separate habits so that the whole performance can be accomplished. The whole method, on the other hand, calls for concentration on the entire task at one time, without separate attention to subsidiary activities.

A vast amount of research in the laboratory, classroom, and industrial plant has been concentrated on determining the relative efficiency of part, whole, and combination part-whole methods. These studies have involved a variety of mazes and several different kinds of verbal material. The maze studies have been carried out with rats, children, and adults. In these investigations the maze has been divided into several parts, the end of each part leading into the entrance of the next. One group of subjects learned part one, then part two, then part three, and finally part four. It then received further training, this time running the maze from beginning to end, until a criterion of learning had been reached. A comparable group, on the other hand, was, from the beginning, trained on the whole maze. A comparison of the results for the two groups indicates the relative effectiveness of the two methods. When poems or other verbal materials are used, the procedure is similar. One group masters one verse at a time, and then combines the verses in further practice, while the comparable group goes from beginning to end of the poem at each trial. One of the combination part-whole methods is to have the subjects learn part one, then part two, then parts one and two; then part three, then parts one, two, and three; and so on. Another combination method is to have the individual go through the whole activity once, then concentrate on parts.

Research on part versus whole learning has had no outcome justifying the generalization that the whole method, the part method, or some combination of whole-part methods is most economical. Even with the same kind of material, the results have not all been in favor of one particular procedure. In one investigation with school-children, it was found that the relative effectiveness of the different procedures depended on the intelligence of the children. For both bright and normal groups, the whole method was superior to the part method, but it was significantly more efficient for the bright than for the normal children.[28] The most adequate statement of the general outcome of research in this field has been given by Woodworth:[29]

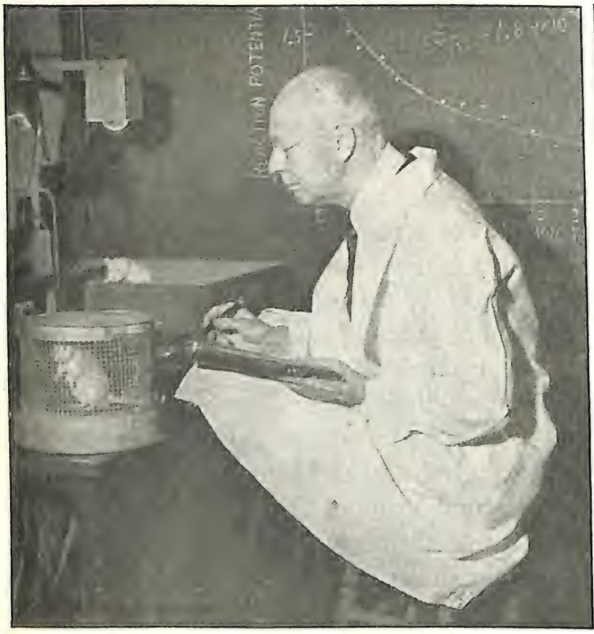
> The net result of all the studies of part and whole learning seems to be something like this: the parts are easier to learn than the whole, and the learner is often happier and better adjusted

to the problem when beginning with the parts. He carries over some of the skill and knowledge gained in learning the parts into the subsequent learning of the whole performance. But he finds that putting together the parts is a serious problem requiring much further work. In the end, he may have saved time and energy by commencing with the parts — or he may not — depending on the size and difficulty of the total task, and on the learner's poise and technique. If he can adjust himself to the whole method and handle it properly, he can learn quite complex performances effectively by the whole method. In a practical situation it is probably best to start with the whole method, while feeling free to concentrate at any time on a part where something special is to be learned.

THEORETICAL ASPECTS OF LEARNING

Not satisfied with a mere description of learning and conditions which facilitate or hinder it, psychologists have long sought to discover *how* it occurs. Some have looked for an explanation in terms of what happens in the nervous system. In other words, they have sought a *neural theory* of learning. But before much progress can be made in that direction it is necessary to find the answers to at least two important questions, both of which concern behavior more than they do the underlying neurology.

One of these questions bears upon *what* the organism learns. Does it learn *responses* which, as learning occurs, are automatically elicited by stimuli, or does it learn the *significance* of stimuli and then respond in terms of its expectation or anticipation of the consequences of certain responses to such stimuli? In other words are learned responses elicited by stimuli as reflexes are elicited, or does their arousal depend upon intervening implicit processes, themselves initiated by stimulation?



Clark L. Hull

Edward C. Tolman

105

Professors Hull and Tolman

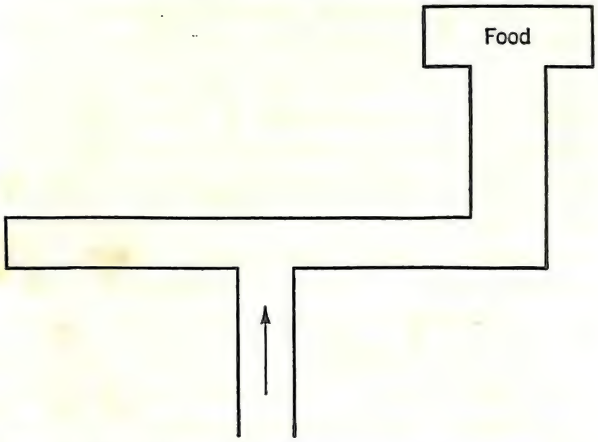
These psychologists have produced the two outstanding theories of learning discussed in the text. Both, as suggested here, use rats in their experimental investigations. (Photos courtesy of Professors Hull and Tolman.)

The second question to be answered before an adequate neural theory can be developed is *how* the organism learns what it learns. In other words, what conditions must be present if learning is to occur? Is contiguity (the close spatial or temporal association of stimulus and response) required? What does repetition do? Must reinforcement (reward or punishment) occur?

Let us view learning theory from a somewhat different angle. We have already said that psychology is concerned with the response of organisms to stimuli, the usual formula being $S \rightarrow O \rightarrow R$, where S is the stimulus; O, the organism; and R, the organism's response. With our attention focused upon learning, we want to know what happens in O when he learns, or makes a learned response. What, in other words, are the events which occur between the time a stimulating situation is presented and the moment the organism makes a learned response? These intervening events have been referred to as *intervening variables.* The chief points of contention concern the nature of these variables and the conditions which produce them. In other words *what* are the variables and *how* do they originate?

Two theories of learning are especially noteworthy. These are the theories of Professors Hull and Tolman (Figure 105). The following discussion shows how Hull and Tolman attempt to answer the *what* and *how* of learning.

Both give a great deal of emphasis to learning by rats. But this does not imply an interest in the rat as such. It merely reflects the view that if we are going to discover the explanation of learning we must begin with relatively simple organisms and simple learning processes. Human beings are neurologically too complex, the experimenter's control over them is too loose, and their behavior is too much shaped by cultural and other social influences to make them good subjects for the preliminary and yet fundamental work of the learning theorist.



106

A Choice-Point in a Typical Maze

Why does a trained rat turn to the right at the choice-point — because a right turn is reflexly aroused by stimuli at the choice-point, or because he "expects" that a right turn will bring food? This is an important issue for learning theory, as shown in the text.

Professor Tolman has implied that rat behavior at a choice-point in the maze provides a good start for learning theory, hence we shall see how the two outstanding theories deal with the learned response of turning right instead of left at a choice-point like that illustrated in Figure 106.

Hull's reinforcement theory

According to Hull, what the rat learns is a more or less automatic turning response to stimuli associated with the maze path. Learning the right turn is believed to require: (1) motivation, such as hunger or the need to escape painful stimulation, (2) occurrence of a right turn, at first random, (3) stimuli in the maze path or within the animal (kinesthetic) which may serve to elicit (becomes cues for) the right-turning response, (4) reinforcement, such as reduction of hunger or escape from painful stimulation, (5) close association (contiguity) of the stimuli, the response, and reinforcement,

and (6) repetition of these conditions. Repetition is assumed to accumulate *habit strength.* For Hull, "the process of habit formation [accumulation of habit strength] consists of the physiological summation of a series of discrete increments, each increment resulting from a distinct receptor-effector conjunction closely associated with a reinforcing state of affairs."[30] Reinforcement may be *primary,* as when the hunger drive is reduced, or *secondary,* as when a stimulating situation associated with drive reduction serves as an incentive in itself.[31]

There is much more to Hull's theory than we have indicated, but the details are too complicated for presentation here. To the question, "What does the organism learn?" Hull answers that it learns to make a response to certain stimuli. To the question, "How does it learn?" he answers that it learns through the gradual accumulation of habit strength, which itself depends upon the activation of receptor-effector processes in close contiguity with reinforcing conditions. The learned response (R) is more or less automatically elicited when conditioned stimuli (S) arouse the neural repositories of habit strength (S^HR). Diagrammatically:

$$\text{S (choice-point)} \longrightarrow S^HR \rightarrow \text{R (right turn)}$$

There are several intervening variables in Hull's theory, but S^HR, defined as "a precise dynamic relationship between afferent and efferent neural impulses," is the most important of them.[32]

Tolman's theory

In at least two respects, Tolman's theory is diametrically opposed to Hull's. In the first place, it denies that what the organism learns is a mere automatic response to stimuli. It maintains that the animal learns the *significance* of the stimuli and that its response is determined by this rather than by the stimuli as such. It learns, in other words, that such and such a stimulus situation *means* food. The stimuli are "signs" or "guide-posts" and not response-releasing triggers. To use Professor Tolman's own phraseology, what the organism acquires is not a response as such, but rather a "cognitive map" which guides it. The organism learns, in other words, a significant place where the food is, or "what leads to what." It acquires information.

Support for this viewpoint comes from Professor Woodworth, who says,

> . . . neither chain reflex nor motor pattern accounts for the rat's behavior in the maze. . . . The most obvious answer . . . is simply that the rat learns the place. By place we mean a concrete situation containing *objects in spatial relations.* By learning the place we do not imply that the animal acquires a memory image which he can call up in the absence of the place; we need not credit him with any power of recognizing a presented object or situation. We credit him with some power of perception or observation, so that he can discover the character of different objects and different parts of the maze. He observes the food-containing character of the food box, the dead-end character of the blind alley, the particular odor of a bit of floor — and the *location* of these parts in relation to each other. The maze, at first a vague total, comes to have parts in definite location and with definite characters.[33]

The learned response of turning to the right is thus assumed to be made in terms of the rat's information, and not in terms of automatically operating neural mechanisms, set off by stimuli associated with the choice-point. Diagrammatically:

$$\text{S (choice-point)} \longrightarrow \text{cognitive map} \rightarrow \text{R (right turn)}$$

In the second place, this theory argues that reinforcement is not necessary for learning, although it may be necessary for utilization of what has been learned (i.e., use of the cognitive map). According to Tolman,

the repeated contiguous association of stimuli and responses, as when the rat is running through a maze, is sufficient for acquisition of knowledge concerning "what leads to what." Drive reduction is not necessary.

Tolman contrasts his viewpoint with Hull's by saying that, according to the stimulus-response reinforcement theorists,

> . . . a hungry rat in a maze tends to get to food and have his hunger reduced *sooner* as a result of the true path responses than as a result of the blind alley responses. And such immediately following need-reductions or, to use another term, such "positive reinforcements" tend somehow, it is said, to strengthen the connections which have most closely preceded them. Thus it is as if . . . the satisfaction-receiving part of the rat telephoned back to Central and said to the girl: "Hold that connection; it was good; and see that you blankety-blank well use it again the next time these same stimuli come in." These theorists also assume . . . that, if bad results — "annoyances," "negative reinforcements" — follow, then this same satisfaction-and-annoyance-receiving part of the rat will telephone back and say, "Break that connection and don't you dare use it next time either."

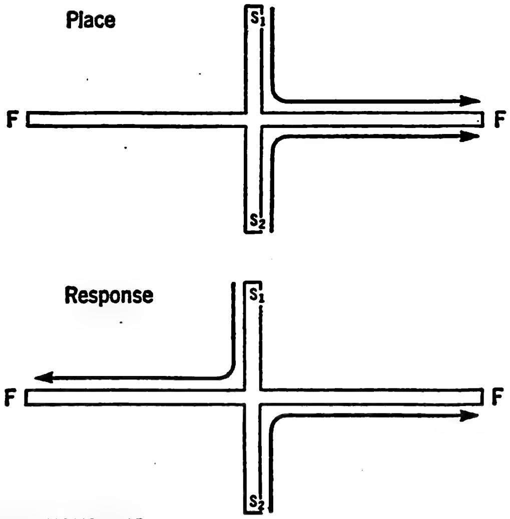
In presenting his own viewpoint, Tolman says,

> We believe that in the course of learning something like a field map of the environment gets established in the rat's brain. We agree with the other school that the rat in running a maze is exposed to stimuli and is finally led as a result of these stimuli to the responses which actually occur. We feel, however, that the intervening brain processes are more complicated, more patterned and often, pragmatically speaking, more autonomous than do the stimulus-response psychologists. Although we admit that the rat is bombarded by stimuli, we hold that his nervous system is surprisingly selective as to which of these stimuli it will let in at any given time.
>
> Secondly, we assert that the central office itself is far more like a map control room than it is like an old-fashioned telephone exchange. The stimuli, which are allowed in, are not connected by just simple one-to-one switches to the outgoing responses. Rather, the incoming impulses are usually worked over and elaborated in the central control room into a tentative, cognitive-like map of the environment. And it is this tentative map, indicating routes and paths and environmental relationships, which will finally determine what responses, if any, the animal will finally release.[34]

There is much evidence to favor the view that organisms learn meanings as well as responses. At a choice-point in the maze, the rat's right turn could be interpreted either as a response to the meaning of the stimuli (in terms of a "cognitive map") or as a response automatically released by the stimuli. To put it another way, the animal might be going where it "knows" the food is located or it might be turned, puppet-like, by the stimuli at the choice-point. It would do the same thing (turn right) whichever interpretation were correct. The difference in these alternatives is brought out in a simple experiment in which learning *where the food is* and learning a *response* led to different results.

Place versus response learning

An elevated cross maze like that illustrated in Figure 107 was used. Eight hungry rats were required always to go to the same *place* (the right arm) for food regardless of whether they were started at S_1 or S_2. All learned the problem and did so quite readily, despite the fact that sometimes a right and at other times a left turn had to be made. What they learned was to make different responses to reach the same place. Eight other rats, comparable with the first, were required to make a right turn when starting from S_1 and also a right turn when starting from S_2. These animals were thus required to learn a *response* (right turn) which, of course, led to a different place depending upon where they started. Only three of the eight learned the problem, de-



107

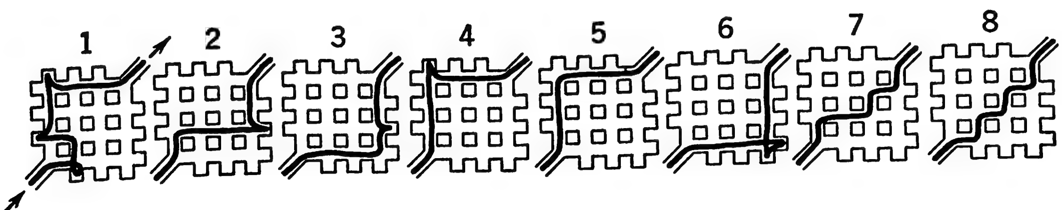
Place and Response Learning

In place learning, either a left turn (from S_1*) or a right turn (from* S_2*) takes the rat to the same place. In response learning, as represented here, a right turn (from* S_1 *or* S_2*) takes the animal to a different place. (After Tolman, Ritchie, and Kalish.)*

spite long-continued training. This experiment not only shows that rats may learn a response, a place, or both, but also that learning a place is easier than learning a response.[35] It does not, of course, prove that either of the theories under discussion is correct.

There is other evidence for the view that a rat in the maze learns where the food is rather than (or in addition to) a series of conditioned responses to particular stimuli. In a maze, like that shown in Figure 108, where several equally short paths to food are available, the animal sometimes takes one path and sometimes another.[36] When short cuts are introduced into a maze like that shown on page 138, rats frequently take a short cut.[37] Thus it appears that the animal is going to a place and not automatically reeling off a series of movements to successive stimuli. Another argument against the view that a mere series of responses is learned comes from experiments in which rats that had learned to run the maze were required to swim it. They followed the correct path despite the fact that new responses were required.[38] Insight, and learning through the observation of skilled performance, also favor the view that something more complicated than conditioned responses to specific stimuli is being elicited.

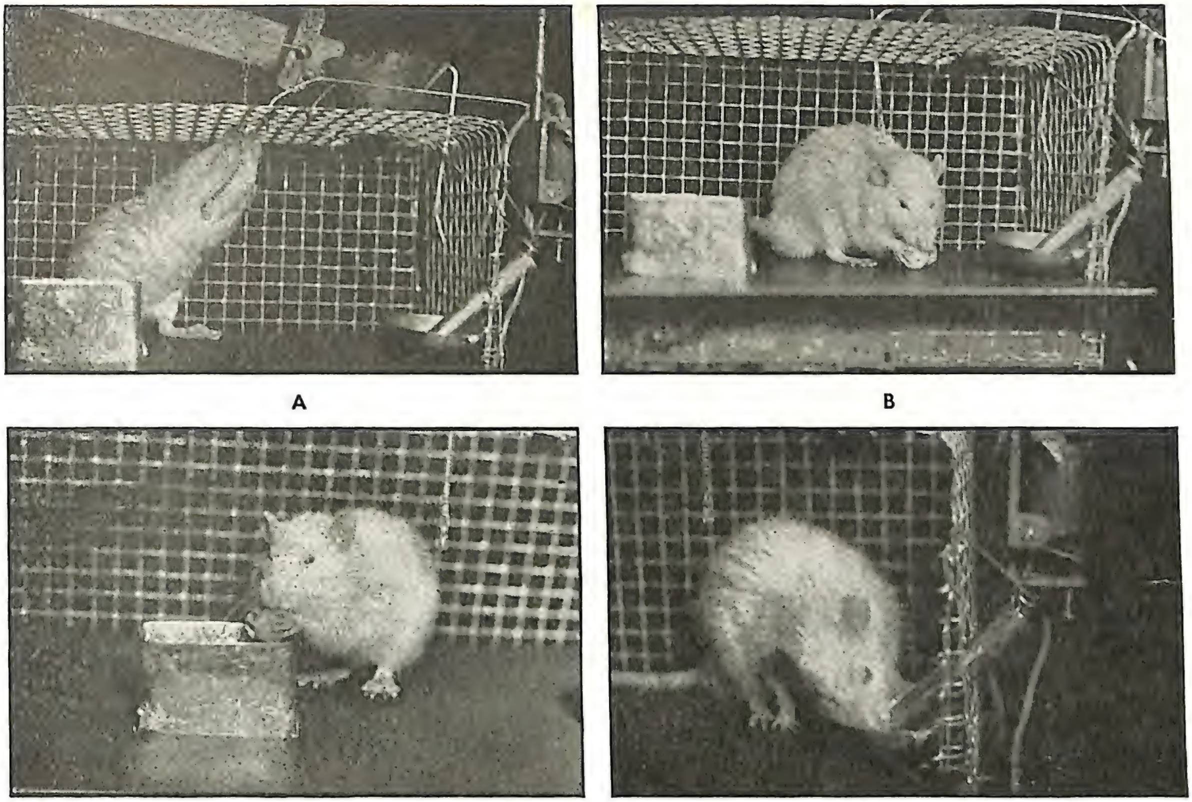
The clearest instance of learning a response, as such, occurs in conditioning where a more or less isolated response, rather than an integrated series of movements, is called for. Contraction of the pupil in response to a conditioned stimulus is one of the purest instances of such a learned response. In instrumental conditioning and problem box learning the responses may be elicited directly by the external stimuli, or they may also be mediated by such intervening variables as



108

Dashiell's Open Alley Maze

Here the same animal varies its route from entrance to food. The first eight runs are represented in this diagram. (From Dashiell, J. F., Fundamentals of General Psychology, *3rd Edition. Boston: Houghton Mifflin, 1949, p. 413.)*



A B C D

109

A Rat is Trained to Exhibit Novel Reactions

A. *Pulling a cord.* B. *A marble has fallen from the rack above and is being picked up in the rat's forepaws.* C. *The marble is carried to a tube projecting above the floor and dropped into it.* D. *The falling marble causes food to fall into the tray where the rat is seen getting his reward. (Research by Professor B. F. Skinner. Photos by William Greer.)*

Professor Tolman's "expectancy." As learning situations become more complex, there is an increasing likelihood that, instead of being elicited automatically, responses will be influenced by such implicit factors as the "cognitive maps" stressed in Tolman's theory.

One additional difficulty with the idea that all learning is reducible to conditioned responses is that, in order that a response may be conditioned, it must already be present. There is no allowance for the fact that responses not already in the organism's repertoire may be learned. Actually animals as well as men learn many responses not already in their repertoire at birth. It is possible (Figure 109) to teach even a rat to do things unlike anything it has ever done before. The investigator here taught the animal to pull a string to obtain a marble from a rack, pick the marble up with its forepaws, carry it to a tube projecting above the floor, lift it to the top of the tube, and drop it inside. To quote the investigator, "Every step in the process had to be worked out through a series of approximations, since the component responses were not in the original repertoire of the rat." [39]

Each of us learns many responses not in

our repertoire at birth. Speech, for example, is not merely a combination of sounds already in the child's repertoire of vocalizations. Many speech sounds (or the movements of vocal mechanisms which produce them) are novel. Many of our manual skills, including the acts involved in writing, also call for novel responses and cannot convincingly be envisaged as chains of reflexes.

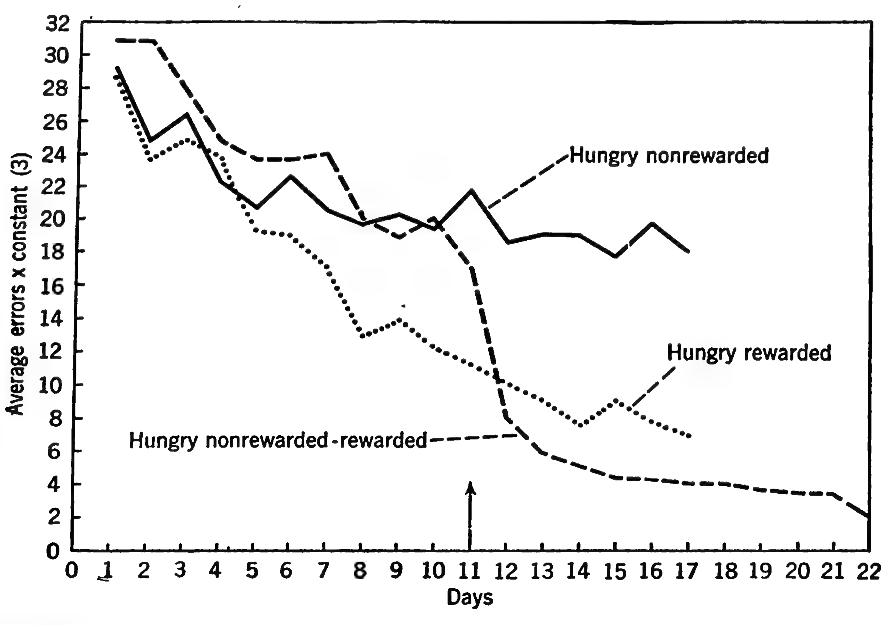
What we have been saying is that knowledge and responses are both acquired and that, the more complicated the learning situation, the greater the likelihood that responses will be novel and organized in terms of the meanings of stimuli as argued by Professor Tolman.*

* Knowledge is itself some sort of complicated and acquired neural response, as the above quotation concerning cognitive maps implies. Nobody is arguing for disembodied ideas. The controversy concerns a relatively simple versus a relatively complex envisagement of learned behavior.

The role of reinforcement

It seems clear that organisms acquire information and that they acquire responses, but what of reinforcement? Is it a necessary aspect of learning? The chief argument for non-reinforcement is provided by experiments on latent learning.

In one latent learning experiment, a food reward was introduced after the animals had received 10 unrewarded trials in the maze. The chief findings are illustrated in Figure 110. Observe that rats of the hungry-non-rewarded group reduced their errors only slightly at the same time that the hungry-rewarded rats reduced them to a low level. The group of particular interest to us here is the hungry-non-rewarded-rewarded group. Before a food reward was given, these also exhibited a relatively slight error reduction. Within one trial after food was provided, however, their errors dropped to the level



110

Some Evidence for Latent Learning

(From Tolman, E. C., and Honzik, C. H., "Introduction and Removal of Reward and Maze Performance in Rats," University of California Publ. Psychol., *1930, vol. 4, p. 267.)*

of the continually rewarded group, which had received twelve rewarded trials.[40]

This sudden improvement suggests that the animals had acquired information which they did not utilize until, after the tenth day, it became advantageous for them to do so. That they acquired this information without reinforcement from food is obvious, since there was no food. But what about other reinforcing conditions? When Professor Tolman argues that their learning was unreinforced, he ignores the fact that certain reinforcing factors are inherent in the maze situation. If the animal has an exploratory drive (or what in a child would be called curiosity) the satisfaction of this drive would itself provide reinforcement. Being removed from the maze, as well as returning to the home cage, might also provide reinforcement. Any hindrance of the rat's ongoing activity, such as running into a blind alley and having to turn to get out of it, might serve as negative reinforcement.

There is other evidence of latent learning, in the sense of acquiring information which is not utilized in overt response until a strong, relevant incentive is offered.[41] But there is no satisfactory evidence that such learning occurs without reinforcement of some kind.

It may well be that stronger or more obvious reinforcement is required for the learning of responses *per se* (as in conditioning experiments) than for the perceptual, incidental or latent learning which Tolman stresses and which is so evident in human beings.

Is there only one kind of learning?

Hull's theory stresses the idea that all learning has a common basis. But Tolman takes the position that at least some aspects of learning are not reducible to Hull's concepts. Several psychologists have argued that there is actually more than one kind of learning.[42] Tolman has said recently that there are actually six kinds, or at least the learning of six kinds of relationships.[43] Two of these are those that we have been discussing; namely, learning to make conditioned responses and acquiring information. Those who follow Hull's lead feel that information, as well as other complicated aspects of behavior, will turn out to be complications of the simpler learning processes with which they deal.

It is too early to say who is right. Only further theorizing and related research will disclose whether all learning, from acquiring a conditioned response to understanding the calculus, can be reduced to the same principles. If such a reduction ever occurs, the principles may be like those of Hull's system or they may be quite different.

Perhaps, out of the current concern over learning theory, a common meeting ground will be found, such as theoretical physicists have achieved in recent years. If the theoretical issues relative to learning are solved, they will have important ramifications for other aspects of psychology — perception, motivation, individual differences, personality, and many aspects of applied psychology.

SUMMARY

In learning any kind of activity, we probably use all of the relevant senses that we have. Some activities, however, are especially dependent on vision, others on hearing. Rats deprived of their visual sense are handicapped in learning a simple elevated maze. They are still more handicapped when both vision and hearing are eliminated. Blind, deaf, and anosmic rats show little learning at all. The kinesthetic sense is important in controlling a habit once perfected, but it is apparently of little use in acquiring a habit

unless supplemented by vision or hearing.

Maze experiments with rats have shown that a decrease in the amount of intact cortical tissue is associated with a decrease in learning ability, and that the effect is greater for more complex than for simpler habits. These experiments also suggest that, so far as the maze habit in rats is concerned, the part of the cortex from which the given amount of tissue is removed is of little or no consequence — that only the amount removed matters.

One interpretation of this finding is that, when any sensory area is destroyed, the rat uses its remaining sensory areas, and, regardless of which area is destroyed, the others together have an equivalent role in learning. Lashley opposes this view and presents data which suggest that destruction of cortical tissue does more than destroy sensitivity. He claims that it interferes with associative activity, and that so far as such activity is concerned, the different regions of the cortex are equivalent in function.

This controversy does not concern certain habits of sensory discrimination, where a particular region, for example, the visual cortex, may be essential. Nor does it apply to recall and reasoning — for the frontal lobes are especially involved in these activities.

Tests given to human subjects who have undergone brain operations fail to show any relationship between the amount of brain tissue removed and the degree of behavioral impairment — a result opposed to what Lashley found for maze learning in rats. The results on localization also failed to agree with Lashley's, for injuries in the frontal lobes produced a greater impairment than injuries to other regions. This discrepancy between rat and human data may be explained by the fact that human beings were given tests rather than tasks to be learned and that these tests involved processes which are known to depend to a greater degree upon the frontal lobes.

It is doubtful whether any learning occurs without motivation. The efficiency of learning (trials to learn, errors made, time consumed, and so on) in animals and human beings is related to the strength of motivation. Generally speaking, the stronger the motivation, the more efficient the learning. Although much research has been done with various kinds of rewards and punishments, praise and reproof, and social recognition and rivalry, one cannot say which of these is the best for any particular situation or individual. Rewards are probably better than punishments, but a combination of the two has yielded better results than either alone. Praise is generally more effective than reproof. Rivalry produces faster learning than no rivalry, but intense rivalry might have disrupting effects. Skills are not acquired unless there is some knowledge of results. Human beings fail to learn many things because the intention to learn is absent. Passive repetition is apparently useless.

Distributed learning is usually more efficient than massed learning. However, the most effective work period and the most effective rest interval between work periods of a given length must be determined for each learning situation. How short a practice period may be, yet produce efficient learning, depends on the individual learner — especially his ability to concentrate quickly on the task before him. Some practical situations call for massed learning, despite the fact that, from the standpoint of the lessons required before mastery, distributed learning would be more economical. Among factors which may contribute to the greater economy of distributed learning as compared with massed learning are: lessened fatigue, better motivation, greater opportunity for neural activities to perseverate, lessened resistance to continuation of the learned activity, and a greater opportunity for differential forgetting of wrong as compared with correct responses.

Recitation usually leads to more efficient learning than passive reading. Some reasons

are: recitation provides intense motivation, a better knowledge of results, an introduction of rewarding and punishing factors, and a practice of what one must eventually do anyhow.

It is not possible to make any definite generalization concerning the relative effectiveness of whole versus part learning. Some activities are learned more efficiently when they are broken up into parts and one part is learned at a time than when tackled as a whole. Others are learned more efficiently by the whole method. Sometimes a combination of part-whole procedures is most economical. However, one person may learn a particular activity more efficiently by the whole method, another person by the part method, and another by a combination of methods. Intelligence and other personal factors may play a part in determining which method is most economical. Even if one favors the part method, it is probably best, before concentrating on the parts, to make an over-all survey of the material or task to be learned.

Theories of learning are especially concerned with *what* is learned (knowledge, or responses, or both) and *how* learning occurs. We considered how two opposing theories, those of Hull and Tolman, envisage the behavior of a rat at a choice-point in the maze. According to Hull's theory, the rat learns a certain response to stimuli and he learns it because one response rather than the other has been reinforced (rewarded). Tolman, on the other hand, supposes that the animal learns the meaning of the stimuli (what they lead to) and not a response, as such. According to this theory, acquisition of the meaning does not require reinforcement, although correct performance (utilization of what the animal knows) does not occur unless performance is rewarded. We saw that rats can learn either a response (right turn) or a place (where food is) and that latent learning experiments yield evidence that an animal may learn more than is apparent in overt performance. We expressed doubt concerning the view that latent learning occurs in the absence of reinforcement.

Some theoretical psychologists now incline to the view that there is more than one kind of learning and that each may require a different explanation. Others, like Pavlov and Hull, believe that all learning is ultimately reducible to conditioned responses. The answer lies in future research on learning in animals and men.

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Part Four

Memory and Thinking

Our discussion of the learning process emphasized acquiring. Now, in turning to memory and the thought processes, we give special consideration to the retention and further use of what has been retained.

Remembering is retaining, although not necessarily retaining of which one is aware, as when he says that he remembers something or as when he sets out to memorize a poem, a lesson or a speech. Many of our learned acts are performed automatically, without any awareness of what we are doing. This is especially true of motor activities. In these instances there is also memory, but memory in the sense of neural retention without involvement of what we shall refer to shortly as "symbolic processes." This retention of which we are not aware, unless our attention is called to it, is sometimes referred to as biological memory.

Without memory in at least the biological sense there could be no learning. Each occurrence of a situation would elicit the same response as before. On each trial, in other words, the organism would, so to speak, "start from scratch." Instead of this there is, as we have seen, a more or less progressive change as training or practice continues. We respond to a previously neutral stimulus, the frequency of correct responses increases, we perform the task with a decreased expenditure of energy, or responses followed by punishment weaken or drop out altogether.

Forgetting is failing to retain what has been acquired. As in the case of memory, it may be evident to us or we may be unaware of it. Considered biologically, forgetting, like memory, is a necessary aspect of the learning process, for we must "forget" incorrect responses while we acquire correct ones. We have already observed that both correct and incorrect responses are partially forgotten during an interval of no practice, and that the incorrect responses are forgotten faster than the correct ones. We shall soon observe that efficient learning brings good retention and that quick learners, everyday opinion to the contrary, usually are good retainers. Such facts emphasize the point that we have been

making, namely, that learning, retaining, and forgetting are interdependent processes. Whatever makes for good learning has this effect because it is conducive to good retention, which is of course the obverse of forgetting.

Remembering and forgetting vary in degree. To all appearances we may retain (or forget) some knowledge or some skill completely, partially, or not at all. We say "to all appearances" because it is impossible to prove that anything once learned is ever completely forgotten. In the next chapter we refer to the recovery of memories going back to early childhood, memories which to all appearances were completely lost.

From learning to retention and then to thinking is a logical transition. Indeed psychologists often refer to the thought processes — to thinking, reasoning and concept formation — as "complex learning processes." These processes naturally fit into the framework of learning and memory for two reasons.

In the first place, they involve recall and manipulation of what has already been learned — recall and manipulation, more specifically, of substitutes for past experience. These substitutes are popularly known as memories or as ideas. Psychologists more often refer to them collectively as "symbolic processes." This is because their most important characteristic is that, like symbols (such as words and numbers), they represent something else. They represent what we have already learned. We shall see that symbolic processes are acquired and used by animals as well as human beings and that, in the latter, they are reported sometimes as images, sometimes as words, and sometimes as neither.

In the second place, the thought processes are themselves instruments of learning. After symbols have been acquired, we combine them in new ways, and still further learning occurs. The manipulating and combining of symbols such as occurs in reasoning is of course an implicit process. Indeed this is what most clearly distinguishes reasoning from overt problem solving. A cat escaping from a problem box after exhibiting trial and error behavior is not said to reason. In reasoning, the trial and error is, so to speak, under cover. Sudden solution of detour and other problems, which we have already referred to as observational learning or use of insight, appears to bridge the gap between overt trial and error learning and learning through reasoning.

Aristotle spoke of man as the reasoning animal; thus implying that animals do not reason. We now know that although reasoning is normally rare in animals, some of them may be induced to reason. We know that they reason because they could not conceivably solve the problems that we set them except through what, in human beings, we call reasoning. Some such problems are considered in the second of these chapters. We shall see that they are also used to test the reasoning ability of young children. It is interesting, in this connection, to observe that a typical child must be from three to five years old before it can solve some problems which a bright adult rat can solve.

9 REMEMBERING AND FORGETTING

Evidences of Memory • Reproducing a Motor Performance • Relearning as Evidence of Memory • The Delayed Reaction: Delayed reaction in monkeys; delayed reaction in infants; recognition tests • Recalling: Recall after a single presentation — memory span; recall of paired associates; recalling narratives; reproduction of forms; testimony; eidetic imagery; the role of stimuli in recall • Recognizing • Retention and Original Learning: Distributed versus massed learning; recitation and retention; speed of learning and retention • Forgetting: Forgetting and the type of material learned; overlearning and forgetting; reminiscence and forgetting • Why Do We Forget?: The effect of sleep; retention and different degrees of activity; retroactive inhibition; emotion and forgetting • Memory Training • Summary

If I ask you to describe the earliest childhood experience which you can remember you will recall events that, seemingly, had been completely forgotten before you began to probe the remote past. Your memories would most likely go no further back than your third or fourth year, although there are some authentic instances of memories going back as far as the first year.[1]

The ability of an organism to retain the effects of experience has led to many theories of the so-called "memory trace," which has also been referred to as a "neurogram" and as an "engram." Most of the current controversy is focused upon the question whether the biological basis of memory is a change in particular cells or synapses or whether it is a change in the patterns of neural excitation. A very recent theoretical discussion argues that the mnemonic trace involves both structural change and a change in reverberating excitation patterns.[2] While the question cannot be settled at this time, it is well to recognize that there are neural memory traces of some kind and that their nature does constitute a problem for psychology as well as neurology.

EVIDENCES OF MEMORY

Memory is a very general term which covers such phenomena as recalling, recognizing and memorizing, as well as retaining of which there is no awareness and no verbal aspect. Suppose, for example, that you learned a poem as a child. You may be able to recall it completely, reciting it word for word, just as you did as a child. Perhaps you cannot recall the poem, even partially, but you can recognize it as one learned in childhood. Among many other poems which you did not learn, it appears familiar. Perhaps you cannot even recognize the poem. But since you learned it as a child, the chances are that you will be able to relearn it with a saving in the repetitions required. That is to say, you memorize it now much more readily than you memorize poems of comparable difficulty which you never before learned.

Evidence of memory in animals and infants comes from a variety of non-verbal criteria, all of which apply to adult memory, although verbal evidences are also available at this level. The animal or the human infant may reproduce some motor performance, it

may relearn with a saving in time and effort some response which it cannot perfectly reproduce, it may respond in terms of absent stimuli, and it may select from a random assortment of objects some object shown to it previously. This is delayed matching in terms of a sample. Our discussion of memory begins with these non-verbal evidences of retention in both animals and human beings.

REPRODUCING A MOTOR PERFORMANCE

Suppose, for example, that a rat or a human being has learned a maze to the point where it can run through the pathway three trials in succession without error. The next day, or a week or a month later, we may wish to see whether the habit has been retained. If the subject can traverse the maze for three trials without error, we say that it remembers perfectly — that there has been no forgetting.

Some rats have retained simple problem-box habits perfectly for as long as a month. Still higher organisms may retain such habits for months or years. Man retains some habits for life. You may not have ridden a bicycle for many years, yet still be able to ride one perfectly well.

How long we retain a motor habit perfectly depends to a large degree on how much we have practiced it. Skills like eating with a knife and fork, buttoning and unbuttoning clothes, and writing are practiced so frequently that, even if something should prevent us from practicing them for many years, they would be retained without noticeable loss.

The almost perfect retention of motor skills over long periods has led some to suppose that such skills are necessarily better retained than verbal skills. That this is not so has been demonstrated in experiments where predominantly verbal activities (memorizing nonsense syllables) and predominantly motor activities (learning mazes) have received equal repetition. Under these circumstances, retention of motor skills is no better than retention of verbal ones.[3]

It has been argued in this connection that human maze performance involves verbal elements (see page 135) and hence that the investigators were comparing one verbal skill with a motor skill which was to a great extent verbal. Pursuitmeter learning (p. 153) is probably less verbalized than maze performance and more recent research has shown that, after equal practice, retention of this motor skill is still far superior to retention of nonsense syllables.[4] It is possible that this superiority of the equally practiced motor task comes from its unitary, highly integrated character. The subject seems to be learning one instead of several things. A list of nonsense syllables, by comparison, consists of several things to be learned. It is piecemeal, or loosely organized. One might expect the more unitary task to show a greater resistance to disintegration during a period of no practice, hence have superior retention. But what happens when motor and verbal tasks are both closely integrated? A recent study involving operation of switches versus memorization of nonsense syllables arranged in a pattern corresponding to the switches was designed to answer this question. Retention of the motor habit was still superior, but not significantly so.[5] The conclusion that one may draw from these studies is that the superior retention of motor skills in everyday life comes from the fact that many of them are overlearned, as compared with verbal skills, and also from the fact that they are better integrated. Still another reason for better retention of motor skills in everyday life is perhaps the fact that most of them are learned under better motivation than most verbal skills. One would expect, in short, that equally practiced, equally integrated, and equally interesting motor and verbal skills would be equally well retained.

RELEARNING AS EVIDENCE OF MEMORY

Suppose that retention is not perfect. Some forgetting has occurred. But how much? The method of determining this is the *saving method.* It is used with animals and human beings.

In order to determine the degree of retention (or forgetting), we require that the task be relearned to the same criterion as that originally involved. Thus, if the maze was learned to the point where it could be traveled three times in succession without error, it is relearned to the same criterion. We then compare the original performance with the relearning performance.

Suppose, for example, that a rat required twenty trials to learn a maze and only five trials to relearn it some time later. The saving is fifteen trials, or 75 per cent of the trials originally required. From the standpoint of forgetting, the rat has forgotten 25 per cent. In one maze-learning experiment with rats, there was a saving in trials and time to relearn which averaged 90 per cent after two weeks, 88 per cent after four weeks, 85 per cent after six weeks, and 73 per cent after eight weeks.[6]

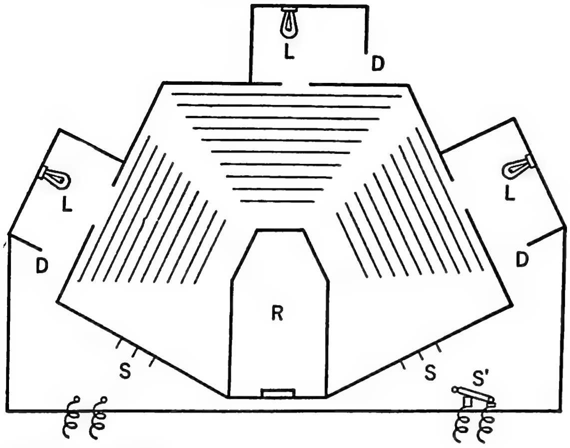
Subjects may learn verbal materials until they can be recited without error. Weeks, months, or years later, the material may be partially forgotten. In relearning it to the criterion of one perfect repetition, and in comparing the repetitions required with those originally involved, the amount or percentage of retention can be determined.

A saving in time and effort required for learning may occur even when the material was originally not learned to the point where it could be recalled, and even where there was no attempt to memorize it. This is illustrated by an experiment in which a psychologist read certain Greek passages to his child between the ages of fifteen and thirty-six months, and several years later required the child to memorize them. Some of the passages were learned at the age of eight and a half years, and others at the age of fourteen years. In each instance the repetitions required to memorize the material read to the child were fewer than those required to memorize new passages of equal difficulty. The average number of repetitions required at eight and a half years was 317 for learning the passages presented earlier and 435 repetitions for learning the new passages, a saving of 27 per cent. In other words, hearing the passages in childhood, although it did not produce learning from the standpoint of recall, led to a saving of 27 per cent when learning to the point of recall was later required. The materials learned at fourteen years yielded a saving of only 8 per cent. Thus, the effects of earlier experience with the Greek passages apparently grew weaker with time.[7]

THE DELAYED REACTION

In the original experiment on delayed reactions in animals, the apparatus represented in Figure 111 was used.[8] The animal was first trained to associate a lighted compartment with food and an unlighted compartment with an electric shock. The lighted compartment varied in position in a random sequence from trial to trial so that the animal could not learn merely by going to the middle door, to the right-hand door, to the left-hand door, or to the three doors in any particular sequence. If it learned this part of the problem at all, the animal did so on the basis of response to the light.

After the subject came to select the lighted compartment at every trial, the delayed-reaction tests were instituted. The light was turned on in a compartment, but turned off before the animal was released. In order to respond to the previously lighted compartment, it was now necessary to remember in which compartment the light had been. If the interval between turning off the light and release was one minute, and the animal consistently went to the previously lighted



Hunter's Delayed-Reaction Apparatus

This particular form of the apparatus was used with rats. The animal, in the glass release box R, *could be stimulated by the lights* L. *It was required to associate a light, appearing in any one of the three doors in a chance order, with the presence of food. An electric shock was administered whenever the animal attempted to enter an unlighted chamber. Food was obtained at the front of the apparatus whenever the correct chamber had been entered. In the training series the release box* R *was raised while the light was still present. After the association between a lighted compartment and food had been thoroughly established, the light was turned off before release. The animal was now required to remember in which compartment the light had appeared. If it continued to go to the previously illuminated compartment, a longer delay between the turning-off of the light and the raising of the release cage was instituted. The time of delay was gradually increased until the animal could no longer remember which compartment had been illuminated.* D, *doors through which the animal made its exit from the light box;* S, *switches connected with grids;* S′, *light switch. (From Hunter, W. S., "The Delayed Reaction in Animals and Children."* Behavior Monographs, *1913, vol. 2, p. 24.)*

compartment in a series of trials, it was credited with remembering for one minute — or recalling after one minute. The delay could then be increased until a marked inaccuracy of performance occurred.

Rats and dogs did not respond correctly after an interval of even a few seconds unless they kept their heads turned toward the correct compartment. This motor set — involving muscle tensions — enabled them to respond correctly. Raccoons and children, on the other hand, did not need to maintain a motor set. They moved around in the release box and, after it was raised, turned and proceeded toward the correct compartment.

In rats and dogs there was no evidence of response to an absent stimulus. Although the light was off, kinesthetic stimuli associated with the fixed position of the body were present to guide them. The raccoons and children, on the other hand, maintained no motor set — hence, they had neither the light nor kinesthetic stimuli to guide them. Controls showed that no other external stimuli were acting as cues. The investigator thus concluded that the raccoons and children were guided by some implicit process which represented the absent light. This he called a *symbolic process*. He defined the symbolic process as "any process which is a substitute, which can arouse a selective response, and which can be recalled if it ceases to be present."

In the case of raccoons and children, something inside of the organism — presumably a modification of the nervous system — substituted for the light. Its function was selective because it guided the animal to the previously lighted compartment — not to any or all compartments. The substitute was presumably not functioning while the raccoons and the children were turning in this direction and that, but it was recalled after an interval.

Rats and dogs, although they failed to exhibit the symbolic process in this situation, have given ample evidence of it in later research, with simplifications of the original technique.[9]

Recent research on delayed reaction in animals and children has utilized a more direct method than that described. It is

more direct in that the subject does not first have to be trained to associate a particular isolated stimulus (like the light) with food.

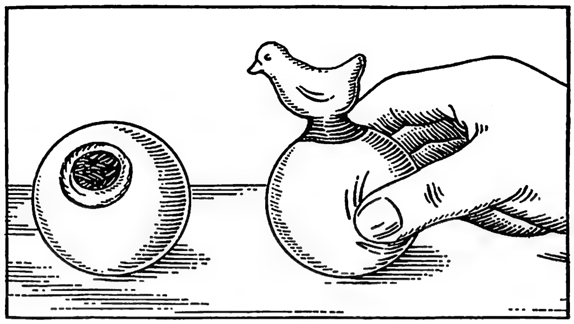
Delayed reaction in monkeys

The monkey sits a short distance from the experimenter. Two cups are placed before it, one to the right and one to the left, or one near and one more distant. While the animal watches, the experimenter slips a piece of lettuce under one of the cups. The animal is now removed from the situation, perhaps taken to another room. Some time later it is returned to the experimental situation and released. If it goes directly to the food cup, the monkey is allowed to eat the lettuce and is credited with a correct response. If the correct cup is selected trial after trial, despite the fact that both cups smell alike, that the food appears under one cup at one time and another at another time, and that no other external cues as to the correct cup are available, we are forced to conclude that the animal remembers under which cup it saw the food placed some minutes or hours before.[10] Stimulation provided by the experimenter's placing of the food must have made some impression on the monkey's nervous system which later served as a substitute for the actual stimulation. The specific nature of the symbolic process is suggested by a further experiment.

Monkeys ate lettuce if they found lettuce after seeing it placed under a cup, but they preferred bananas to lettuce. "What would the monkeys do," the experimenter asked, "if they saw a piece of banana placed and found lettuce when they returned to the situation later?" When they found the lettuce under these circumstances, the monkeys usually refused it. They left it where they found it and walked away. Sometimes they examined the vicinity as if looking for the missing banana. Temper tantrums were occasionally exhibited. Children behaved in a somewhat similar fashion when a non-preferred reward like a chocolate drop was substituted for a jelly bean. Sometimes, however, they asked about the exchange of rewards.[11]

Delayed reaction in infants

Memory in infants between the ages of three months and two years has been tested by presenting some stimulus, then, minutes later, observing whether the child shows any signs of missing the stimulus. The best tests of this nature involve the materials shown in Figure 112. An infant is presented with the ball containing the chicken. As he or the tester squeezes the ball, a chicken pops out of the hole. After the child has had plenty of opportunity to observe the chicken, the ball is taken away. Other activity is then aroused. The ball is finally returned, but this time without a chicken to pop out. Recall is assumed to be present if, upon squeezing the ball or observing the tester squeeze it, the child shows surprise, looks questioningly at the tester, looks into the hole, or



112

Materials for the Delayed-Reaction Test in Infants

The child is shown that a chicken pops out as the ball is squeezed. Then a similar-appearing ball, but with no chicken, is substituted. Recall of the chicken is assumed to be present if the child shows surprise at its absence, or looks inside the ball for it. (After Buehler, C., and H. Hetzer, Testing Children's Development from Birth to School Age. *New York: Farrar and Rinehart, 1935, p. 142.)*

pokes its finger in, as if looking for the chicken. Maximum intervals after which the chicken is recalled range from around three minutes at fifteen months to seventeen minutes at two years.[12]

Between two years and five there is a very great increase in the duration of intervals after which recall occurs. In one experiment in this age range, three plates were used.[13] The child saw a cooky being placed under one plate, which varied in position in different trials. After intervals ranging from one day to over a month, the child was returned to the situation and asked to locate the cooky hidden previously. Some five-year-old children were consistently accurate after intervals of a month or more. They were greatly helped by language, itself a symbolic process. A child might say to himself, for example, "The cooky is under the middle plate." During the interval of a month or so, he might not think of the situation any more. Upon being brought before the plates, however, he might say, "Oh, yes, I saw it placed under the middle plate." Recall in older children and adults often occurs after years. Language probably plays a large role in reinforcing whatever symbolic processes are present in animals and in infants before language is acquired.

Recognition tests

Subjects are presented with a sample (for instance, a form) and are later called upon to identify it among a variety of other items. The subject shown in Figure 113 was first trained to lift an object in order to obtain food. Several objects were used in this way. Then the subject was taught to lift an object resembling whatever sample was shown. A triangle was shown and then removed. Several seconds or minutes later, the subject was confronted with a triangle and several other forms. In order to be scored correct, the subject must lift the triangle and not

113

Delayed Matching from Sample

In the delayed matching-from-sample test, the object at the left is first shown by itself. It is then removed and the forms to the right are shown. In order to recognize which of these forms was seen earlier, the subject must remember what the original form was. Sometimes the forms are all of the same shape but different in color. At other times they may differ in both shape and color. Then the subject must remember not only the shape of the sample but its color as well. (After Weinstein, B., "Matching From Sample by Monkeys and Children." J. Comp. Psychol., *1941, 31, p. 198. Photos courtesy of H. F. Harlow.)*

touch the circle, square, or other forms presented with it. A circle, let us say, was then shown. Later, it was presented with other forms. Now, the circle must be lifted and the triangle and other forms left untouched.[14]

When children are used in such experiments, they may be instructed to "find the form like the one I showed you a few minutes ago." They must then point to the form, or other object, resembling the sample.[15]

RECALLING

Tests of the delayed reaction are too simple for use with older children and adults. Recall at these levels is tested by using nonsense syllables, words, digits, forms, or more complicated verbal or symbolic materials.

Recall after a single presentation — memory span

The simplest type of recall test with verbal materials is found in memory span tests. The subject may be presented with a series of digits gradually increasing in length. Each list is given only one presentation. When the auditory memory span for digits is tested, the digits are read off by the tester. As soon as the end of the series is indicated, the subject tries to repeat the digits vocally or in writing. Thus if the experimenter reads, "0 4 1 6 2 8 5," the subject attempts to reproduce these numbers in correct order.

The first series may have four digits, the next five, the next six, and so on up to a series of a dozen, as in the following sample, which you may use to test your own or another's memory span.

7152
16529
531584
9152693
86103279
726394105
6574398961
40315806296
374691705824

The memory span for digits is the longest group of digits one can recall in correct order, regardless of the length of the series read to him. He may recall the entire series until he gets to six or seven; but he may get eight out of the list of a dozen. His span for that presentation is then eight. The span will differ somewhat from presentation to presentation, hence an average of several tests is often taken.

When the visual memory span for digits is measured, the subject is shown the digits, one at a time, perhaps by means of an apparatus like that illustrated earlier (p. 152). He then recalls them orally or in writing. The same general procedure is used in testing the visual memory span for words, syllables, forms, or other materials.

Memory span differs with age and with the type of material used. For example, the average span for auditory presentation and vocal recall of digits is four between four and five years, five between six and eight years, six between nine and twelve years, and seven beyond twelve years.[16] When familiar objects are presented, one at a time, and named by the child as they appear, his memory span is about five at five years and eight at thirteen years.[17]

Recall of paired associates

Suppose that the following pairs of English words and transliterated Russian equivalents were shown, one pair at a time, and you were asked to learn the Russian associate of each English word:

SKULL	CHEREP
EYE	GLAZ
SKIN	KOZHA
BRAIN	MOZG
FOOT	NOGA
HEAD	GOLOVA
MOUTH	ROT
BONE	KOST
HAIR	VOLOS
BACK	ZAD

After one repetition of the list of associates, you might be given the first members of the pairs in a changed order and asked to recall their associates. You might recall a few of the Russian words after this single presentation, but you would not recall all of them. After each successive repetition of the pairs, however, you would probably recall more associates. Finally, you would be able to recall the Russian equivalent of every English word. The number of associates recalled on successive tests would, if plotted against the number of repetitions, yield a learning curve.

Recalling narratives

Children and adults read or hear narratives which they later attempt to recall, either orally or in writing. Recall after a single reading is like a test of memory span, although connected rather than disconnected material is involved. When the narrative is read or heard repeatedly and a recall is required after each repetition, we have something like the typical memory experiment in which increased retention occurs as a function of repetition. A learning curve may be plotted for such data. Sometimes, however, recall is required at intervals of minutes, hours, days, or weeks, after a single presentation of the narrative. This is to see how forgetting proceeds, and whether or not distortions are introduced as a function of time and repeated recall. A still further variation of memory experiments with narratives is to have one individual read or hear the narrative, then tell it to another who, in turn, tells it to still another, and so on. In this way, changes introduced as the story passes from one to another, as when rumors pass from mouth to mouth or legends are handed down from generation to generation, may be investigated.*

* Some excellent examples appear in collections of ballads where those sung by successive generations have been noted. See Child, F. J., *English and Scottish Popular Ballads*. Boston: Houghton Mifflin, 1904.

In one extensive investigation involving the above procedures, university students read stories, then attempted to reproduce them.[18] For example, a student read the following story two times, then engaged in other activities for fifteen minutes. His reproduction after fifteen minutes follows the original story.

ORIGINAL STORY

The Son Who Tried to Outwit His Father

A son said to his father one day: "I will hide, and you will not be able to find me." The father replied: "Hide wherever you like," and he went into his house to rest.

The son saw a three-kernel peanut, and changed himself into one of the kernels; a fowl coming along picked up the peanut and swallowed it; and a wild bush-cat caught and ate the fowl; and a dog met and caught and ate the bush-cat. After a little time, the dog was swallowed by a python, that, having eaten its meal, went to the river and was snared in a fish trap.

The father searched for his son and, not seeing him, went to look at the fish-trap. On pulling it to the riverside, he found a large python in it. He opened it, and saw a dog inside, in which he found a bush-cat, and on opening that he discovered a fowl, from which he took the peanut, and breaking the shell, he then revealed his son. The son was so dumbfounded that he never again tried to outwit his father.

REPRODUCTION

The Son Who Tried to Outwit His Father

A son one day said to his father: "I will hide, and you will not be able to find me." His father replied: "Hide wherever you wish," and went into the house to rest.

The son saw a three-kernel peanut, and changed himself into one of the kernels. A fowl saw the peanut and ate it. Soon afterwards a bush-cat killed and ate the fowl, and then a dog chased and finally killed and ate the bush-cat. After a time a python caught the dog and swallowed it. Soon after its meal, the python went down to the river and was caught in a fish-trap.

The father looked for his son, and when he could not find him, he went to the river to see whether he had caught any fish. In his fish-trap

he found a large python which he opened. In it he found a dog in which was a bush-cat. On opening the bush-cat, he found a fowl, in which he found a peanut. He opened the peanut, and revealed his son.

The son was so dumbfounded at being discovered that he never tried to outwit his father again.

Observe that the reproduction retains the theme of the story and the succession of events. However, certain words, like the "wild" bush-cat, are omitted entirely; synonyms for others, such as "wish" in place of "like," are given; and some words — and ideas — are added which were not in the original. For example, the original does not say that the fowl was killed and eaten by the bush-cat "soon after" the fowl ate the peanut. All it says is that the bush-cat caught and ate the fowl. After successive repetitions of such materials, each recall gives more and more details and, in general, accurate reproduction is approximated. But when successive recalls by the same individual occur without any further presentation of the original, increasing distortion of details is introduced.

Some of the investigator's conclusions from his analysis of a mass of such data are: (1) "accuracy of reproduction, in a literal sense, is the rare exception"; (2) "the general form, or outline, is remarkably persistent, once the first version has been given"; (3) "style, rhythm, precise mode of construction . . . are very rarely faithfully reproduced"; (4) "frequent reproduction, omission of detail, simplification of events and structure, and transformation of items into more familiar detail, may go on almost indefinitely"; and (5) "in long-distance remembering, elaboration becomes more common in some cases . . . and there may be increasing importation or invention . . . aided by the use of visual images."

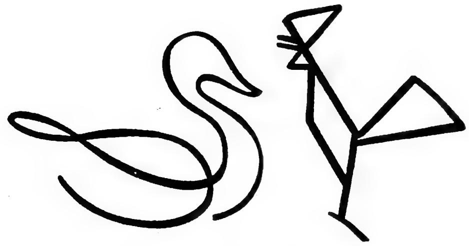
When the individual reads or hears a narrative, then tells it to another, and that one tells it to still another, and so on, the theme may be retained, but there is usually a marked distortion of details. The following reproduction of "The Son Who Tried to Outwit His Father" illustrates the point. It was obtained from the twentieth person who had heard the story, so to speak, chain fashion:

A small boy, having got into some kind of mischief, wished to hide himself from his father. He happened to be standing under a tree, when an acorn fell to the ground, and he immediately determined to hide himself within it. He accordingly concealed himself within the kernel. Now a cat chanced to be passing along that way, and when she saw the acorn, she forthwith swallowed it. Not long afterwards a dog killed and ate this cat. Finally the dog himself was devoured by a python.

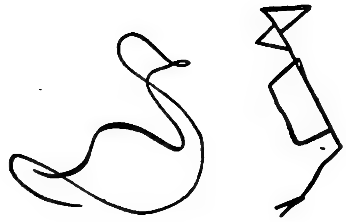
The father of the boy was out hunting one day when he met the python, and attacked and slew it. On cutting the beast open, he discovered the dog inside it, and inside the dog the cat, and inside the cat the acorn. Within the acorn he found his long-lost son. The son was overjoyed at seeing his father once more, and promised that he would never again conceal anything from him. He said that he would submit to the punishment he deserved, whatever his crime might be.

Reproduction of forms

In Figure 114 are shown two figures and their reproduction after they had been observed for one minute. An experiment on the memory of college students for such forms was conducted along the lines of the experiment on narratives. Successive repetition brought an increasingly faithful reproduction of the original. However, successive reproduction after one presentation brought omissions, additions and inaccuracies reminiscent of those found when narratives were repeatedly recalled. The main outline or general schema was retained. For example, if a man was pictured, the reproduction was of a man, although markedly different from the original. One tendency which stands out in such reproductions is that the reproduction becomes increasingly conventional. This is



COCK AND SWAN
Original



COCK AND SWAN
Drawing from memory

114

Reproduction of Form

This is typical of the experiments on memory for form which Sir Frederic C. Bartlett has published in his book Remembering. *Here the subject was shown the original drawing and, after it had been removed, asked to reproduce it. Observe that the general features, or the themes, have been retained but that certain details have been changed or omitted. (Suggested by the experiments of Sir Frederic C. Bartlett.)*

also true when, as in the case of narratives, the picture is passed on, chain fashion, to a number of subjects, each of whom reproduces it from memory and then shows his reproduction to another.[19]

Testimony

Many studies have been made of the ability of children and adults to describe or otherwise report events witnessed just once. The situation is somewhat like that of testifying about accidents or other events while in a courtroom. Still or moving pictures may be used. Sometimes, however, a carefully rehearsed scene is enacted before the group, without any knowledge on their part that it is acted, and without any expectation, either, that they will be called upon to testify concerning the event.

Descriptions of still pictures, movies, scenes enacted, or actual events are in most instances grossly inaccurate, and they become increasingly so with a lapse of time between the original experience and the reproduction.

You may test your own accuracy in the following way: Some time ago you looked at a picture showing Pinel casting chains from the insane. Before looking at the picture again, write a description of it. Better still, show the picture for one minute to someone who has not already seen it. Then have him recall it in writing. Comparison of what is recalled with what was actually witnessed will undoubtedly show much discrepancy.

Sometimes the subject is given a list of statements or questions concerning the scene witnessed. He then attempts to say whether the statements are true or false or to answer the questions. Recall in these terms also shows much inaccuracy. The degree of inaccuracy is often related to the way in which the question is framed.

Test yourself or your subject with the following statements about the Pinel picture. Each statement is to be labeled true or false.

1. There are stairs in the picture.
2. A woman is kissing Pinel's left hand.
3. Pinel has a walking cane.
4. One woman is being whipped by an attendant.
5. Some of the women are still chained.
6. Five trees are shown in the picture.
7. The attendant is removing a metal band from a woman's waist.

8. Several women are shrieking loudly.
9. A large heap of chains and shackles lies on the floor.
10. Pinel is accompanied by soldiers with guns.

Inaccuracy of recall, under circumstances like the above, has several possible bases. (1) Observation was perhaps incorrect in the first place, leading to omission of certain details and to the addition of others. (2) Interests, attitudes, and expectations of the observer may have influenced both observation and recall. An architect looking at the Pinel picture may be greatly impressed by the architecture and recall aspects of this rather accurately. On the other hand, his observation and recall of facial expressions and other aspects of the behavior may be much less accurate. A psychologist might observe facial expressions and remain unaware of architectural details, thus recalling the latter with relative inaccuracy. Anyone who knew that the inmates were whipped to "drive the devil out of them" might falsely "recall" that he saw one of the women being whipped. If the person knew about Pinel's reforms, however, he would be likely to say that any statement to this effect was false, not because he actually failed to see a woman being whipped, but because he knew that such a scene would be inconsistent with the presence of Pinel. The person who knew that Pinel cast chains and shackles from the insane might, whether he observed it or not, "recall" that a heap of chains and shackles was lying on the ground before Pinel. Previous knowledge and expectations in line with it thus distorts the testimony. (3) Unintentional elaboration or exaggeration may have occurred. Individuals may "recall," for example, that Pinel's hand was raised in a dramatic gesture befitting the importance of the event. (4, As time elapsed, forgetting may have occurred. The omission of details occurs because of forgetting. When details are forgotten, moreover, we may try to fill out the gaps in what we remember. Anything which seems reasonable in the light of what we do remember is "recalled." (5) The individual may have been misled by suggestions, either occurring spontaneously or given by the questions asked. The question might be, "Was the heap of chains near the dungeons or was it under the trees?" Some subjects might "recall" that the chains were in front of the dungeons and others that they were under the trees. It is likely that most who were "caught napping" by this suggestive question would say that the chains were near the dungeons — for this spot seems more logical than the other.

Eidetic imagery

Sometimes, especially in a large proportion of children under six years of age, testimony is exceptionally accurate — almost as accurate, in fact, as if the child could still see the scene after it has been removed. The child reports that he still sees the picture. These exceptionally accurate "memory images" have been called *eidetic,* a term which suggests that they possess the clearness of hallucinations.*

The most common test of eidetic imagery is to present some very detailed picture like that shown in Figure 115, then to remove it and ask the child to describe what he sees, or to answer questions concerning it. The eidetic child seems to project the picture on any convenient surface and to describe what he sees. Even a complicated word (Gartenwirtschaft, for example) may be spelled out forwards or backwards. Acoustic as well as visual eidetic images are sometimes reported.[20] A child with acoustic eidetic imagery will repeat long lists of digits after hearing them once. As described to me by a colleague, one eidetic child looked at the

* In hallucinations the individual sees, hears, or feels things that are not actually present, yet he believes them to be present. The person with an eidetic image, even though it may be as clear as an hallucination, does not necessarily believe it to be a perception of things actually present.

115 **Picture Used to Test Eidetic Imagery**

This picture was used by Gordon Allport in his research on eidetic imagery. Each of his child subjects saw the picture for only 35 seconds. (The report of this research is published in Allport, G. W., "Eidetic Imagery." Brit. J. Psychol., *1924, 15, pp. 99–120. Courtesy of Dr. Allport.)*

desk while a list of a dozen or so digits was being read to him, then "read" them off forwards and backwards while still looking at the desk.

Eidetic imagery is rarely present in older children and adults. Something akin to it perhaps exists in people who report a "photographic memory" like a student who told me that, after reading an assignment, she could see the material before her and "read" it again in imagination.

The role of stimuli in recall

In our discussion of the delayed reaction, we pointed out that the subject recalls an absent stimulating situation. This does not mean, however, that recall is without stimulation. The point is that the part of the situation recalled is absent. Other stimuli are necessary for recall. Thus, in the experiment with raccoons, the light recalled was not present at the time, but the experimental situation with its three compartments, the hunger of the animal, and other extraneous yet associated stimulating factors were present. In an entirely different external situation, or in the same external situation when not hungry, the animal in all probability would not recall the light.

Stimuli for recall may be external or internal. You may see a redheaded girl, and the redness of her hair may make you recall a childhood sweetheart whose hair was red. You may smell the odor of some flower that once grew in your home garden, then recall the garden. These, and innumerable examples that one might give, illustrate recall elicited by an external stimulus.

But you may have a stomach-ache and recall the green apples you ate as a child. You may be nauseated for some reason and recall that trip across the Atlantic during which you were violently seasick. These instances illustrate recall elicited by internal stimuli.

Recall of one experience often serves as a stimulus for recall of another. This phenomenon is sometimes referred to as *free association.* When we indulge in free association, we may recall many early experiences which we have not recalled for years. The success of psychoanalysis in getting better recall of childhood experiences than normally occurs comes from their use of free association. They have their patients "think out loud" and sometimes keep them at it during séances spread out over months or years.

Reduced cues. Any fraction of some previously experienced situation may, by itself, lead to recall of a whole experience. This phenomenon is variously referred to as *redintegration, recall in terms of reduced cues,* or *response to minimal cues.* As illustrated in Figure 116, our redintegrative ability enables us to recall (or perceive) a whole situation in terms of significant parts. To use our previous illustration, red hair, the odor of a perfume, the sound of footsteps, or any

other single aspect of some friend, may lead to complete recall, not only of the friend, as such, but also of former experiences to which she contributed. In delayed reaction situations (pp. 201–204) the present stimuli apparently serve to redintegrate the absent ones so necessary to the correct response.

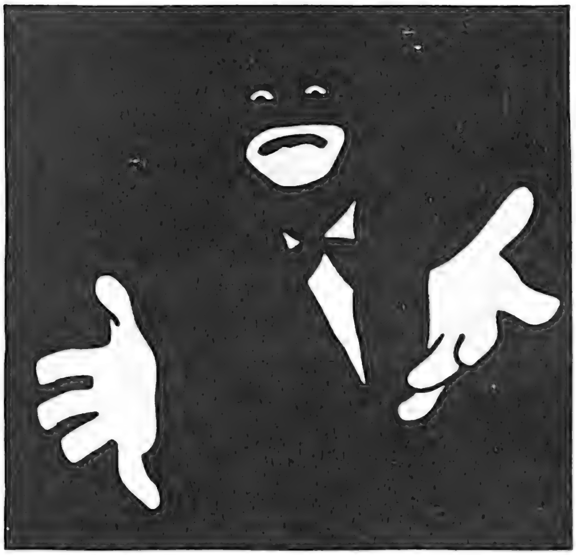
RECOGNIZING

Recognizing is much easier than recalling. This is why examinations of the matching and multiple-choice variety are easier than essay examinations covering the same material. The student has all the material before him, he does not have to recall it. His task is merely to differentiate between the familiar and the unfamiliar, or what has been experienced before and what is new.

In the typical experiment on recognition memory, the subject is shown nonsense syllables, words, forms, or other simple materials. He is given one or more complete presentations, the items usually being presented one at a time as in experiments on recall. The items involved in these trials are then presented among new items, the new and the old being mixed up in a random order. Now the subject must indicate which of the items appeared originally.

You may try this test yourself. Examine each of the faces in Figure 117, allowing yourself one minute for the whole group. Then turn to page 608, and record the number of every face that you recognize as having been in the first group.

So-called *false recognition* is another example of response to reduced cues. We may "recognize" a person as our friend because of some similarity to the friend, such as hair-color, walk, build, or dress. Some aspect of former stimulation involving our friend leads us to recall him, and at the same time to identify the present person with the one recalled. The feeling that one has been in a certain place before or that he has done or said something before, even though he knows that this is the first time, has a similar basis. Something in the present situation or present behavior may be identical with, or very much like, something that occurred previously. This present aspect of former stimulation or activity leads us to recall the original experience and we incorrectly identify it with the present one. False recognition of this sort may be basic in the report of many mystic experiences in which individuals believe that they have recognized persons known in some previous incarnation.



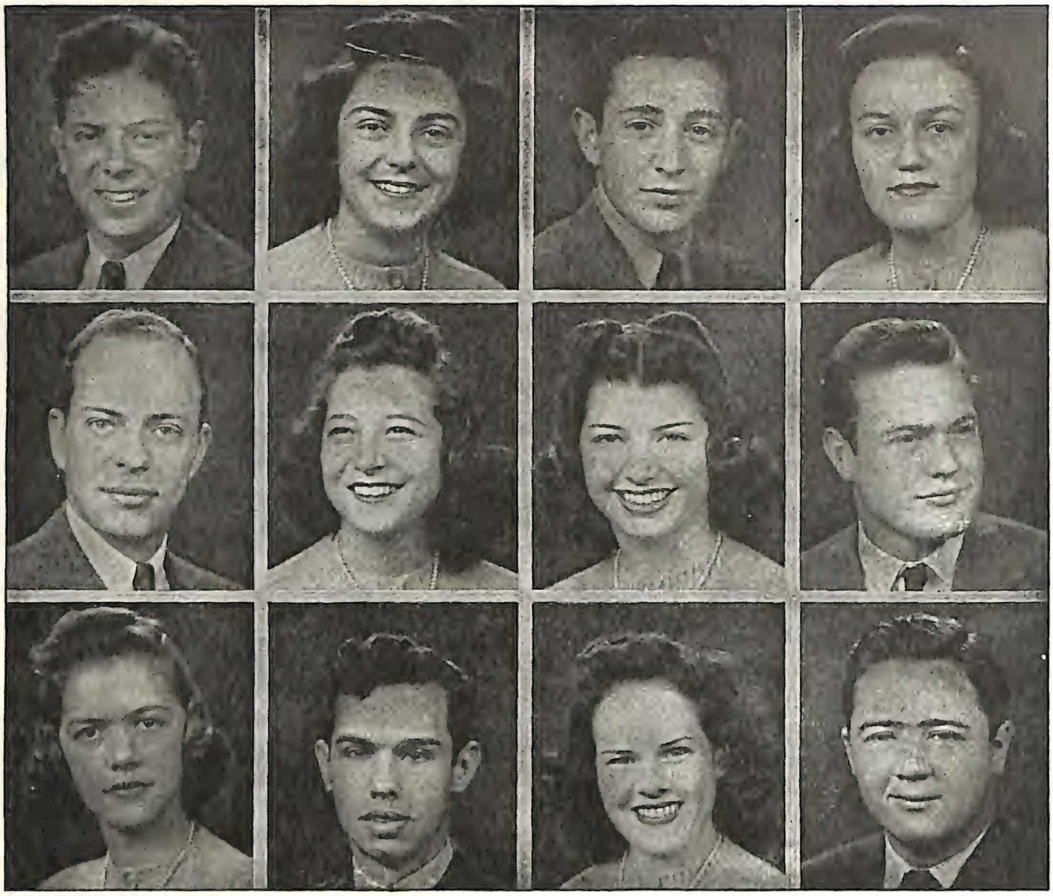
116 **Recall in Terms of Reduced Cues**

(From Dockeray, F. C., Psychology, p. 230. Copyright 1942 by Prentice-Hall, Inc.)

RETENTION AND ORIGINAL LEARNING

Any activity which produces a poor impression obviously yields poor retention. The poorly motivated subject learns little, and, when tested for retention, later, retains little. But even where motivation is good, the most economical method of learning usually yields the best retention.

We have already considered how distributed learning and recitation facilitate



117

Test of Recognition Memory

Look at these faces for about one minute; then turn to p. 608 of Appendix, and see how many you recognize. (Photographs used through the courtesy of the Vanderbilt Commodore.)

learning. Now we see that they also improve retention.

Distributed versus massed learning

Thirty-two college students memorized lists of nonsense syllables to the point where they could recall the lists perfectly. They learned comparable groups of syllables by the distributed and by the massed method of practice. Some lists were recalled after an interval of ten minutes, and still others after an interval of twenty-four hours. The same lists were then relearned to the original criterion — namely, one perfect repetition. The results were quite clear-cut. After every interval, the average recall score for distributed practice was higher than the recall score for massed practice, despite the fact that learning with distributed practice involved fewer repetitions. There was a suggestion, too, that the difference in favor of distributed practice became greater as the interval between original learning and recall increased. In terms of repetitions required to relearn, distributed practice was again better than massed practice. As in the case of recall, this was true after each interval

between learning and relearning. Although the above discussion refers to group averages, most individuals also recalled more and relearned faster when practice was distributed.[20]

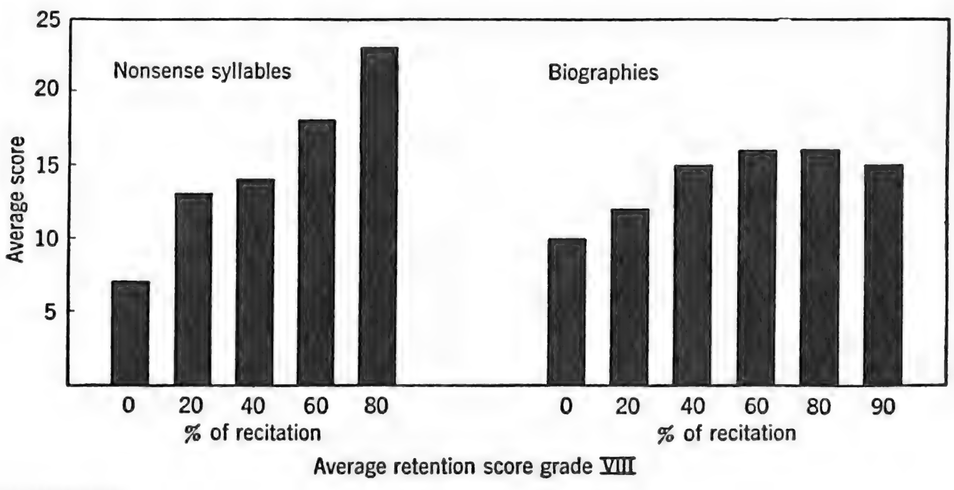
Recitation and retention

We have already described an experiment in which the most efficient learning (immediate retention) of nonsense material occurred with 80 per cent recitation; and the most efficient learning of biographical material with from 40 to 90 per cent recitation. It is interesting to observe, therefore, that retention after four hours was best for the percentages of recitation which had already proved most efficient in learning. This is shown in Figure 118.[21]

Speed of learning and retention

Do slow learners retain better than fast learners who, of course, have fewer repetitions of the material to be learned? Some methods of investigating this question favor the slow learner by giving him as much time as he wants, hence an opportunity to overlearn. Other methods favor the fast learner by giving him more to retain. In other words, when a given time is allotted for learning, the fast learner will acquire more than the slow one, hence have more to retain, with the likelihood of a better retention score. Overlearning, and the amount learned may, however, be held constant through the method known as *adjusted learning*. All of these methods, whether they favor the slow or the fast learner, and whether or not they involve adjusted learning, show fast learners to be better retainers than slow learners.

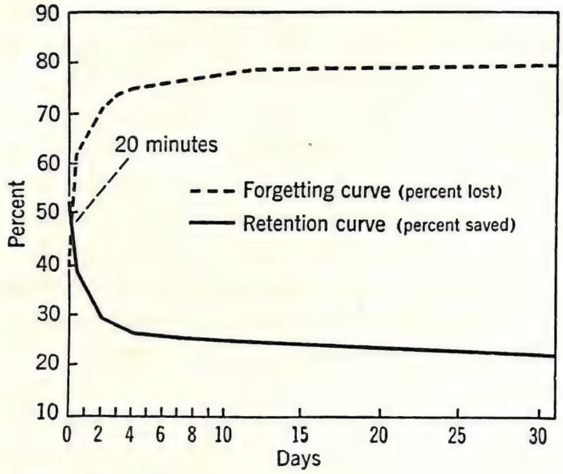
In an experiment utilizing the method of adjusted learning, twenty-five children were required to associate a different number with each of a series of pictures so that, given the picture, they could recall the appropriate number. As soon as the child associated a number with the picture, the picture was withdrawn from the series for that child, the aim being to prevent overlearning. Fast



118

Retention as a Function of Recitation

The retention score for nonsense syllables increases with each increment of recitation, but the comparable score for biographical material reaches its limit with 60 per cent recitation. All amounts of recitation were, however, better than none at all. (Data from A. I. Gates.)



119

Retention and Forgetting Curves for Nonsense Material

Two curves are shown to illustrate the fact that retention is the obverse of forgetting; in other words, that forgetting is "negative retention." (Data from Ebbinghaus.)

and slow learners were similarly treated. The experiment continued until each child had learned approximately ten associations. This guaranteed that slow and fast learners would acquire an equal amount, hence have an equal amount to retain, or forget. The slowest seven of the subjects required an average of 5.7 repetitions, the eleven in the middle required an average of 3.7 repetitions, and the fastest seven required an average of 2.9 repetitions to get the ten associations. Retention was tested after twenty-four hours by both the recall and relearning methods. The average number of associations recalled by the slowest group was 1.7; by the middle group, 3.1; and by the fastest group, 3.9. These differences between recall scores for the fastest and slowest learners were shown by statistical analysis to be significant. The average number of repetitions required to relearn was 3.4 for slow, 2.5 for middle, and 2.1 for fast learners. There was a statistically reliable difference between the lowest and highest averages.[22]

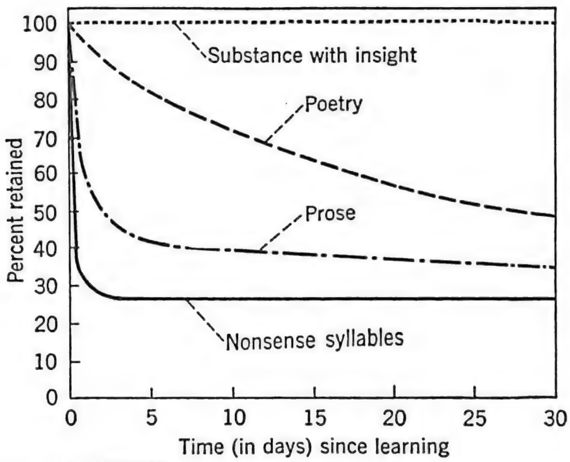
FORGETTING

Forgetting is negative retention. A retention curve drops as a function of time. Such curves are customarily used to represent the course of forgetting. If forgetting were plotted directly, in terms of the amount forgotten as a function of time, the curve would rise rather than fall. A comparison of retention and forgetting curves is given in Figure 119.

In the classical experiment on forgetting, Ebbinghaus memorized many lists of nonsense syllables. He relearned certain lists twenty minutes after he had memorized them to the point of one perfect repetition. Other lists were relearned a day after, some two days after, and so on. The intervals used, and the savings in time to relearn after each interval, appear in Figure 119. About 47 per cent was forgotten in twenty minutes, 66 per cent in one day, 72 per cent in two days, 75 per cent in six days, and 79 per cent in thirty-one days. These results show that forgetting of nonsense syllables is at first rapid (47 per cent lost in twenty minutes) and then slow (only 32 per cent more lost in a month).[23]

Forgetting and the type of material learned

In Figure 120 are summarized the results of several experiments on forgetting of different kinds of material. It is apparent that retention of nonsense syllables is poorest and that it declines most rapidly. Prose comes next, and then poetry. With insight (or understanding), early forgetting is seldom present. For example, college students learned various puzzles (match tricks) either by memorizing the solutions or by memorizing the principles involved. The majority of those who memorized without understanding the principles exhibited marked and rapid forgetting within a month. On the other hand, most of those who learned the



120

Retention Curves for Different Types of Material

The more meaningful the material memorized, the better the retention. The uppermost curve, representing almost perfect retention, is for material completely understood. (From Guilford, J. P., General Psychology. *New York: Van Nostrand, 1939, p. 409.)*

principles had almost perfect retention when tested later at intervals up to one month.[24]

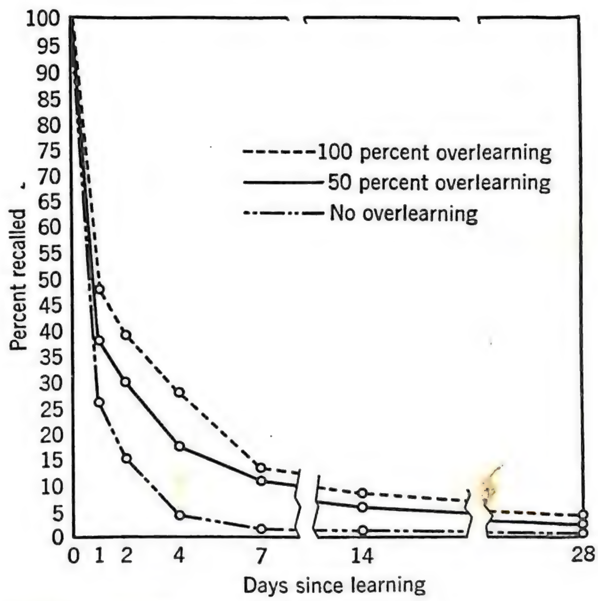
Overlearning and forgetting

Suppose that twenty trials are required to memorize some material so that you can recall it correctly just once. What would be the advantage, if any, of having an extra ten trials — 50 per cent of overlearning? Would you retain 50 per cent better than without it? Ebbinghaus and several later investigators have found that there are decided advantages from overlearning.

The value of overlearning for retention is illustrated by an experiment in which adult subjects learned lists consisting of twelve monosyllabic nouns. They learned with different amounts of repetition beyond that required for the first perfect recall.[25] The criterion of learning was one perfect repetition of the list. Having one half as many repetitions again as were required to reach the criterion was designated 50 per cent overlearning. Having twice the number of repetitions required for learning was 100 per cent overlearning. Thus, if four repetitions allowed the subject to reach the criterion of learning, six repetitions would constitute 50 per cent overlearning, and eight repetitions 100 per cent overlearning.

Different groups learned comparable lists of nouns with 0, 50, or 100 per cent overlearning. Recall and relearning occurred (in different groups) at intervals of one, two, four, seven, fourteen, and twenty-eight days. Figure 121 shows the retention curves for recall when overlearning was 0, 50, and 100 per cent. Somewhat similar results were found in the case of repetitions saved during relearning.

It is quite clear from these data that larger amounts of overlearning bring larger degrees of retention. If we consider recall scores after the interval of a day, we find



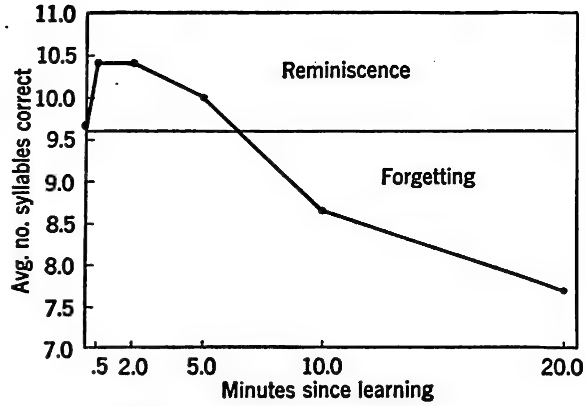
121

Retention as a Function of Overlearning

(From data in Krueger, W. C. F., "The Effect of Overlearning on Retention." J. Exper. Psychol., *1929, vol. 12, p. 74.)*

that there was 26 per cent retention for 0 overlearning, 38 per cent for 50 per cent overlearning, and 49 per cent for 100 per cent overlearning. Taking the results as a whole, the increase from 50 to 100 per cent overlearning (a 33 per cent increase in the number of repetitions) brought less than a 33 per cent increase in retention. Thus diminishing returns were evident. This fact is apparent in the curves. Note that there is a wider space between the 0 and 50 per cent than between the 50 and 100 per cent curves.

A later investigation followed the same experimental design, but involved mazes instead of words.[26] The results were in fairly close agreement with those already indicated. In this study, however, 200 per cent overlearning was also introduced. The results show quite clearly that diminishing returns occur as overlearning is increased. For example, an increase of 100 per cent overlearning (100 to 200) brought an increased retention which averaged less than 50 per cent.



122 **The Phenomenon of Reminiscence**

(After Ward, L. B., "Reminiscence and Rote Learning." Psych. Monog., *1937, 49, p. 30.)*

Reminiscence and forgetting

In all of the experiments so far considered, the material was learned completely before retention was tested. A list of nonsense syllables, for example, was learned to the point where it could be recalled with an accuracy of 100 per cent. Suppose, however, that it had been learned to an accuracy of only 70 per cent. Quite obviously, there can be no better retention than 100 per cent of something completely learned, but it is conceivable that a person who learned something so that he could give a performance that was 70 per cent accurate might perform later with an accuracy greater than 70 per cent. Indeed, there are many experiments which show that this is the case. Better retention of *incompletely* learned material after a rest interval than immediately after learning it has been found in experiments with children, human adults, and animals and using both motor and verbal skills.[27] Improved retention after an interval has been called *reminiscence*. It is illustrated graphically in Figure 122, which represents the retention of an incompletely learned list of nonsense syllables by college students.

Reminiscence is perhaps related to the phenomenon of better learning and retention after distributed than after massed effort (pp. 212–213) and also to the well-established fact that interrupted activities are recalled more frequently than completed activities.[28] The explanation of these apparently related phenomena is not clear. It is possible that rehearsal of the material during an interval accounts for some reminiscence, but it still occurs when rehearsal is prevented, by having the subjects perform some other activity during the interval. It also occurs in learning by rats, which could hardly be credited with an implicit rehearsal of what has been learned. Perseveration, and consequent consolidation of what has been learned, could conceivably account for some reminiscence, but the fact that it occurs when other activities intervene rules out perseveration as a necessary basis. The explanation stressed in recent discussions is

one already mentioned in connection with distributed learning — the marked tendency for incorrect, hence interfering, associations to drop out during a rest period.

Reminiscence is, of course, only a temporary improvement in retention. It is followed by a more or less rapid loss such as occurs after completed learning.

WHY DO WE FORGET?

The first answer to occur is that we forget because the neural traces of previous experience grow fainter with a lapse of time. It is by no means certain, however, that lapse of time, as such, causes forgetting. It is much more likely that other activities which occur within the interval weaken neural traces and make us forget. In other words, time may be an important factor in forgetting, merely because of the activities which occur in time. Numerous experiments have shown, in fact, that relative inactivity following acquisition decreases forgetting.

The effect of sleep

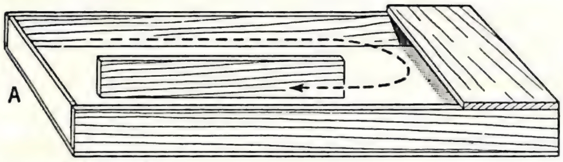
Two subjects memorized lists consisting of ten nonsense syllables before a period of (1) normal daily activity or (2) sleep. Retention was tested after one, two, four, and eight hours of either waking activity or sleep. Under each of these conditions different lists of nonsense syllables were learned and recalled, but they were all of comparable difficulty. Each duration of sleep yielded better retention than a comparable duration of waking. After the successive intervals of sleep, the percentages of nonsense syllables recalled were: 70, 54, 55, and 56. There was, as we see, no further forgetting after the one-hour interval of sleep. The comparable percentages for waking were: 46, 31, 22, and 9. Forgetting was greater, the longer the interval of waking. These findings have been verified in later research. The investigators concluded that "forgetting is not so much a matter of the decay of old impressions and associations as it is a matter of the interference, inhibition, or obliteration of the old by the new." [29]

The fact that forgetting occurs during sleep, even though it occurs less rapidly than when we are awake, is, of course, no basis for discrediting the idea that interpolated activity rather than time itself causes forgetting. Although we are not engaged in learning new activities while asleep, our nervous system is active.

Retention and different degrees of activity

The subjects of the experiments on sleep did not go to sleep immediately, although they tried to do so. It has since been claimed that if it were possible to put the subjects "into a dreamless sleep immediately after learning, so that no new experiences would have an opportunity to interfere with, inhibit, or obliterate the old, a perfect retention might be expected." [30] The same writers point out that "Because of the dangers of drugs, anesthetics, and other methods of inducing unconsciousness quickly, no one has thus far attempted to realize these conditions with human S's, but with animals the case is different." [31] The animals used for a test of the activity theory of forgetting were cockroaches. They were selected because they could be rendered inactive without the use of drugs or other agents which might have deleterious effects on the nervous system. The method of rendering them inactive after learning had occurred was extremely simple. They were placed in a state of tonic immobility (animal hypnosis)* by inducing them to crawl between layers of tissue paper. Sheets of tissue paper were placed in a box which could be entered through a cone. The inducement to enter

* For an interesting discussion of "animal hypnosis" in insects and other animals see Hartman's article "Playing Possum" in *Scientific American*, January, 1950, pp. 52–55.



123 **Learning Box**

A correct response involved following a path like that illustrated, rather than entering the shaded area, where a shock was received. (After Minami and Dallenbach.)

was escape from bright light. While in contact with the sheets of tissue paper the cockroach was perfectly motionless. When the period of inactivity was to be terminated, the animal was removed from the tissue paper and tested for retention.

What the cockroach was trained to do was to avoid the shaded area at the end of the box shown in Figure 123. Its natural response, when placed at A, is to run toward the shaded area at the end of the alleys. But when it ran into this area, the animal received an electric shock through the floor. When it failed to move toward the shaded area, it was pushed. Gradually the cockroach learned to avoid shock by swerving around the end of the glass partition and returning to A without entering the shaded area. Each animal was trained until it turned around the partition, instead of entering the shaded area, for nine trials out of ten. Control groups were normally active during rest intervals. The intervals, for different groups, varied from 10 minutes to 24 hours. Retention was measured in terms of the savings in trials and in the number of shocks administered during relearning.

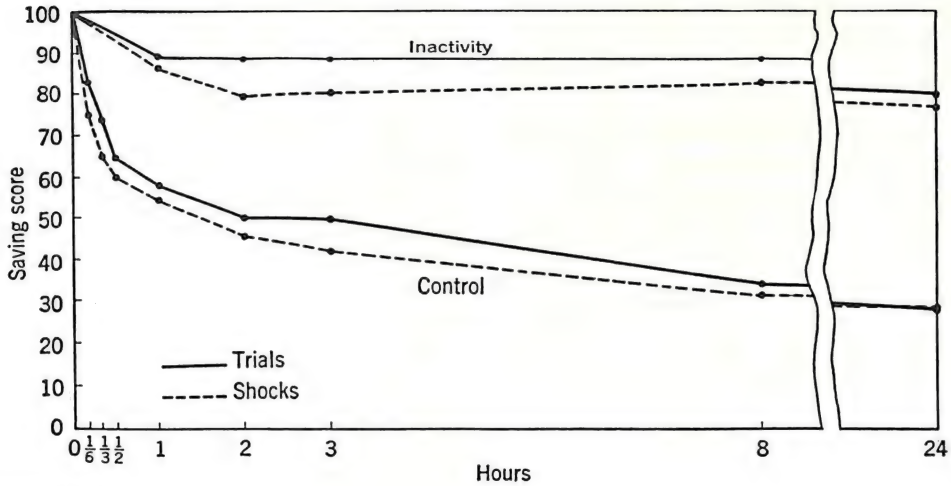
The results of this experiment are summarized in Figure 124, which shows the saving score (retention) of the dark-avoidance habit for the inactive and control groups over intervals up to 24 hours. It is apparent (1) that the inactive group retained very much more than the active group and (2) that whereas the inactive group showed no further loss of retention between two and eight hours, the active group retained less as further time elapsed.[32] These results of course favor the view that forgetting comes from interpolated activity and is not due to a mere lapse of time.

Retroactive inhibition

Experiments on retroactive inhibition provide further evidence for the view that forgetting is due to interpolated activity. In a typical experiment on retroactive inhibition, two equivalent groups memorize the same list of nonsense syllables (list A). One group (experimental) then learns another list of nonsense syllables (list B). While they are doing this, the control group rests, perhaps singing or telling stories, so as to prevent rehearsal of list A. After the experimental group has learned list B, both groups recall all they can of list A. Under these conditions, the recall score for the experimental group is much lower than that for the control group. This applies rather uniformly to individual scores as well as to group averages. Thus, learning list B appears to obliterate, to some extent, the neural traces produced in the learning of list A.

A recent extensive investigation shows that retention is better when a rest period is interpolated immediately after learning.[33]

One thousand school-children, separated into equated groups, studied twenty-five verbs and then recalled all they could after twenty-one minutes and after twenty-four hours. The experimental group studied a list of nouns for seven minutes of the interval. Some of the experimental group studied the nouns immediately after studying the verbs, others studied them following a rest of four minutes, and still others following a rest of eight minutes. Thus, the interpolated learning came at different intervals after learning. The control group sang familiar



124

Active and Inactive Animals–Savings Scores

This shows the savings in trials to relearn and in shocks administered (errors) during relearning after each of the indicated intervals. (From Minami and Dallenbach, "The Effect of Activity upon Learning and Retention in the Cockroach." Am. J. Psychol., *1946, 59, p. 2.)*

songs during the entire twenty-one-minute period.

Retention scores (ratios) were as follows: 121 for controls and between 50 and 69 for experimental groups. The lowest retention score within the experimental group was for interpolated study immediately after learning. The longer the rest period between learning and interpolated study, the higher the retention score. Retention after twenty-four hours showed little loss for the control group, but a large loss for the experimental group. Again, the longer the interval of rest between learning and interpolated study, the higher the retention score.

Various investigations have shown that there is also a relation between the degree of forgetting and the similarity of the interpolated activity to that involved in original learning. With a very high degree of dissimilarity (as between memorizing words and singing), there is relatively little retroactive inhibition. With a high degree of similarity (as between memorizing nonsense syllables and memorizing other nonsense syllables), there is usually a large degree of retroactive inhibition. Within these extremes the relationship between degree of similarity and degree of retroaction is a complicated one which we need not consider here.

Emotion and forgetting

The obliterating effect of emotion-provoking situations, presented immediately after learning, is suggested by the following experiment: College students, working one at a time in a small lighted darkroom, were given several repetitions of a list of nonsense syllables, after which they recalled as many syllables as possible. Following this recall, they were sometimes given jokes to read, none of which was highly mirth-provoking. They were then asked to recall the syllables again. At other times, and quite unexpectedly, they were given a marked emotional upset after recalling a list of syllables just presented. The back of the chair collapsed, an electric shock was felt in the arms, scrap metal fell from the ceiling to the floor, a

pistol shot rang out, and the lights went off, producing total darkness. All of this happened simultaneously. As soon as the commotion ceased, the subject was again asked to recall all of the syllables that he could remember. With the emotion-provoking situation interpolated between first and second recalls, retention was decreased more than under the control condition. In some individual cases there was a very large decrease. After experiencing the situation described, one subject forgot every syllable in the list.[34]

MEMORY TRAINING

Almost everybody would like to improve his memory. Some want to remember names and faces better. Salesmen would like to remember "selling points" better. Public speakers would like to remember their speeches — or at least remember outlines — so that they could avoid reading them. Students would like to remember better the important points of a lecture or of an assignment. They would like to be able to read lists of French verbs, say, and remember them without a large amount of study. And they would like to have better success in recalling the foreign equivalents of English words, or vice versa. It is not surprising, therefore, that thousands of people buy courses whose authors promise improved memory.

One of the best-known "memory experts" has made his living for over twenty years teaching people how to "improve their memory." Various large firms have employed him to improve the memory of their salesmen or other employees. Among these are the Coca-Cola Company, the Standard Oil Company of New Jersey, the Penn Mutual Life Insurance Company, and the Fisher Body Corporation. If you read his book, which describes his copyrighted "system," you will see that the system is an application of the psychology of learning to specific situations which salesmen, public speakers, and students meet.[35] This "system," and others like it, facilitate remembering, not by developing some hypothetical entity called "memory," as a muscle might be developed by exercise, but by teaching people to utilize various devices which facilitate learning and recall. In the last analysis, whatever success is achieved by use of such devices is achieved because the efficiency of learning is increased.

If you follow principles like those involved in any memory system, you may improve your "memory," but, if such improvement does occur, your "memory" will return to its former efficiency (or should we say, inefficiency?) whenever you fail to use the principles. So-called memory training has value only to the extent that it induces efficient learning. Sheer memorizing of something, with the idea that it will improve memory as exercise improves a muscle, is a waste of time. This was amply demonstrated in an experiment on college students.[36] One group which memorized various materials "by heart" showed no improvement later in memorizing similar materials. On the other hand, a group which learned to apply efficient principles of learning while memorizing did show an improvement in later memorizing. The improvement came because principles learned while memorizing one set of material were applied to memorizing the other. This is an example of transfer resulting from application of principles. Some of the principles involved in this experiment and a few additional ones are summarized below.

(1) Have the intention to learn. Suppose, for example, that you are introduced to Mr. Flynn. The person introducing him says, "I would like you to meet Mr. Flynn." In all probability you will say, "How do you do," "Pleased to meet you," or something similar. You may not even have listened to the name. You may have listened, but without hearing it correctly. But this does not disturb you. "After all," you ask, "why should I remem-

ber his name? Mr. Flynn is of no importance to me. I may not meet him again, anyhow." But if you do meet him, you will almost surely not remember his name. The reason is not that your memory is poor, but that you failed to learn the name in the first place. Whenever you hear, read, or observe anything only incidentally, the chances are that your memory of it will be poor. In this connection, think of what was said earlier about failure to remember lists of words when intention to learn was absent.

(2) If you have the intention to learn, you will probably pay close attention to what is before you. If it is important for you to remember Mr. Flynn's name, you will probably listen attentively as the name is spoken. Students often fail to remember what the lecturer is saying, or what they are reading, because their thoughts are elsewhere. Very frequently, too, they are so concentrated on the task of taking detailed notes that they miss the substance and meaning of what is presented. The best procedure here is to listen or read primarily, and to give only secondary attention to note-taking. Notes should be taken only at intervals — whenever something seems especially important. Some of the poorest students have the most detailed notes. Unless you are attending to what is presented, you do not know what is important and you mechanically jot down notes of which you may later have little, if any, understanding. Remember that there is relatively little forgetting when we understand, and that we cannot understand unless we attend closely to what is presented.

(3) Use imagery to the fullest possible extent. Try to get a photographic impression of Mr. Flynn which may be revived later. Notice his eyes, his hair, how he is dressed, and so on. If he has a particular accent, that may help you to recall. Some systems advise picturing him doing something ridiculous, the more ridiculous the image the better — but more about this later. It is well for you to visualize as much as possible what you hear and read. If you hear or read, for example, that a child making a delayed reaction is responding to an absent stimulus, try to picture the situation, first with the stimulus present and then with it absent. You will then probably remember what we mean by a delayed reaction. The advantage of movies and other forms of visual education is that they facilitate acquisition of relevant visual imagery.

(4) Tie up what you are learning with other things. In other words, develop as many associations as possible. William James [37] once said:

> In mental terms, the more other facts a fact is associated with in the mind, the better possession of it our memory retains. Each of its associates becomes a hook to which it hangs, a means to fish it up by when sunk beneath the surface. Together they form a network of attachments by which it is woven into the entire tissue of our thought. "The secret of a good memory" is thus the secret of forming diverse and multiple associations with every fact we care to retain. But this forming of associations with a fact, what is it but *thinking about* the fact as much as possible? Briefly, then, of two men with the same outward experiences and the same amount of mere native tenacity, the one who THINKS over his experiences most, and weaves them into systematic relations with each other, will be the one with the best memory.

Individuals sometimes marvel at how an expert in some field can read a new book in a couple of hours and retain what they could retain only after a course of intensive study. The reason for the expert's "better memory" is, of course, his background in the field. He has, as it were, many hooks on which to hang what he reads. The newcomer to the field must "start from scratch."

Most memory "systems" give major emphasis to association. Some of these advise one to memorize a list of logically related words. First this list is mastered thoroughly, so that it can be said forward and backward, and the word in any position (sixth, forty-

first, and so on) can be recalled without hesitation. Then each new thing to be remembered is, as it were, "hooked" onto one of these words or placed in the appropriate "file." If a list of "selling points" is to be memorized, for example, the first is associated with the first word in the list and the second with the second word, and so on. The first words, being so thoroughly retained, are recalled quite readily. In being recalled, they tend to bring the respective "selling point" with them.

In stressing association, most memory systems utilize the idea of getting vivid, even ridiculous associations in addition to those provided by the "filing system" or the series of "hooks."

Here is an example of associations as an aid to recall, but without any prearranged system of words or other symbols such as most systems contain.[38]

Let us suppose that we have to remember the following French verbs: *venir, acheter, couper, appeler, munier, songer, porter, recevoir, courir,* and *manger* — ten of them. Rather a problem, but not so hard if we use our little trick. Let us choose a room in the chemistry laboratory, to start with. You enter and there is a big can of veneer on the table. Make the imagery plain. You carry that can to the other end of the room and empty it into the professor's ash tray (*acheter*). You then cross the hall into the next lecture-room and are surprised to find a huge chicken coop (*couper*) in the middle of the room; and, while you watch, in comes the chemistry assistant and feeds the chickens on green apples (*appeler*). You become disgusted at seeing a chemistry laboratory so abused and go outside. You are astonished to see that the moon (*munier*) is about three times its natural size, and, while you look at it, the man in the moon starts singing a song (*songer*), whereupon a hotel porter (*porter*) comes up and packs the moon into a big valise, takes it out back of the campus, and dumps the valise into a reservoir (*recevoir*). Now for *courir*. Not so easy. Let's see; you send a courier to the president for help and you go along with him. But, when you enter the president's house, you are astonished to find that you are in a manger (*manger*). That is certainly an exercise in the imagination, but those words will stick. So will any similar list if worked out with reasonable care and reviewed once or twice; but be sure and visualize clearly.

Write down the list of French verbs in correct order. You will probably get several more than you would have retained without the associations given above. Here, however, someone else made up the associations for you. But what if you had to devise them yourself? It might have taken you more time to make up your story than to memorize the words in the first place by routine methods. That is the chief difficulty with "memory systems" — the associations are artificial, and, while learning the system or making up your peculiar associations, you might be learning more directly what you wish to remember. In any event, such systems are valuable only in memorizing lists or outlines, or associations like names and faces. They are of little or no use if you want to recall material which does not fall into obvious sequences.

(5) Rhythm is an aid to retention. This has been shown in several laboratory researches and it is exemplified in the theme songs of radio advertising, like "Dentyne chewing gum, Dentyne chewing gum . . ." The writer was taught the multiplication table in a sort of sing-song and this no doubt helped it stick. There are decided limits, however, to the application of rhythm in learning.

(6) Distribute your learning as much as possible. If you can avoid it, do not cram. You may "get by" the next day, but the chances are that you will not retain very much over longer periods. In the light of what we know about distributed learning as compared with massed learning, it is safe to say that, other things like intelligence being equal, the student who distributes his learning over days or weeks will do better on the examination and also retain better weeks, months, or years later than the stu-

dent who crams the material the day before. Regardless of the basic factors which make distributed better than massed learning, there are also other advantages to distributing one's study. For one thing, the crammer does not have time to tie it in with past experience, nor does he have much chance to rehearse what he is learning.

(7) Wherever possible, rehearse or recite. We have already pointed out the advantages of recitation as compared with passive reading. Recitation not only facilitates learning, but it aids retention. In attempting to remember names and faces, recitation is especially advisable. You should not only intend to remember the name and attend closely so as to get it correctly, but you should also take every opportunity to recite it. You should certainly say, "How do you do, Mr. Flynn," rather than merely "How do you do." If you are engaged in conversation long enough, you may get in a good bit of repetition. You might at least say, "I have so much wanted to meet you, Mr. Flynn," "Good-bye, I hope I shall have the pleasure of meeting you again, Mr. Flynn." The more times you can say the name, the better your chances of recalling it later.

(8) Rest, or, better still, sleep after you have studied. From what we know about the obliterating effect of interpolated activities, it is poor practice to study one subject immediately after getting through with the study of another. There should at least be a pause in which anything like study is avoided. It is especially bad to load up a whole morning with classes, one hour after the other. As much as possible, each class should be followed by rest unless the following class is quite dissimilar to the one that preceded. There is no harm, for example, in following mathematics with physical education, art appreciation, or something of that nature. But if it can be avoided, one should not follow it with some other subject requiring intense application.

(9) When a long chapter is to be studied, look it over as a whole, before beginning intensive study of the parts. If it has a summary, read this before reading the chapter. You may find that you do better not to concentrate on parts, but to read the material through from beginning to end each time. However, the findings on whole versus part learning do not warrant the categorical statement that it is better to learn by wholes than by parts. It depends on you, and on the kind of material you are learning.

SUMMARY

Remembering in the general sense is retaining. Where verbal learning is not involved, as in animals and infants, retention may be measured only through reproduction of motor skill, a saving in time and effort required to relearn, delayed reaction, or delayed matching in terms of a sample. Delayed reaction is recall memory, and delayed matching in terms of a sample is recognition memory. In older children and adults, we may study recall and recognition by using verbal materials like nonsense syllables, digits, and words. Poems, narratives, and actual or pictured events are also used in research on recall in children and adults.

Recalling is responding in terms of absent stimuli. It is made possible by some modification of the organism which represents past stimulation. Thus, the subject in a delayed-reaction situation may respond in terms of an absent stimulus (light, seeing food placed, and so on) because, while the stimulus was present it modified him in some way. The modification, since it represents something other than itself, has been called a symbolic process. When the adult recalls digits, words, or other symbols that he has learned, he likewise responds in the absence

of the stimuli which previously modified him. It is this modification which enables him to "play back," as it were, the original stimulating conditions.

Memory span increases with age, and with the meaningfulness of the material to be recalled. Recall of narratives presented once is usually inaccurate as to details, dropping some details and adding others, but the general theme is well retained. The same is true in recall of form. When narratives or forms are presented repeatedly, and each presentation is followed by recall, the reproduction becomes increasingly accurate, and we may plot a learning curve. Successive recall following a single presentation, however, becomes increasingly inaccurate. This is more evident if the successive reproductions are by different persons who, as it were, have received the material secondhand. Here again, the general theme of the narrative or picture is usually retained.

Testimony concerning events witnessed just once is highly inaccurate. Some of the reasons for this inaccuracy are: incorrect observation, variations in interests and attitudes, unintentional elaboration in "recall," forgetting, and response to suggestions, such as are involved in questions designed to aid recall or, at times, to mislead the person making the recall.

Eidetic imagery is an unusually accurate recall, in terms of visual or auditory imagery, of things previously perceived. Eidetic images have the vividness of hallucinations. They are prevalent in young children but rare in adults. So-called "photographic memory" is perhaps eidetic.

Although we recall objects and situations in their absence, this does not mean that recall is without stimulation. Even when we recall some absent aspect of the situation, as in delayed-reaction experiments, other associated stimuli are present. It is noteworthy in this connection that any fraction of some former stimulating situation may be sufficient to elicit recall of the whole situation. This is response in terms of reduced cues.

In recognizing, we differentiate between the familiar (the old) and the unfamiliar (the new). This is much easier than recalling something in its absence. False recognition shows the influence of reduced cues. Some aspect of former stimulation sometimes makes us feel that we are familiar with a new person or situation.

Procedures which make for efficient learning also facilitate retention. This has been illustrated by reference to the superior retention which comes from distributed learning and the use of recitation in learning. Fast learners are better retainers than slow learners, even under conditions where overlearning and the amount learned are controlled. Overlearning aids retention, but there are limits to the value of large amounts of overlearning. Increased amounts of overlearning sometimes bring diminishing returns from the standpoint of retention.

In the broadest sense, forgetting is failing to retain. You may say, "I have forgotten so and so," because you cannot recall it, but your nervous system may retain it to the degree that you can recognize it or, failing this, relearn it with a saving in time or effort.

Forgetting of nonsense materials is at first rapid, then relatively slow. The course of forgetting tends to be slower, the more meaningful the material learned. In the case of learning with insight or understanding, forgetting may be negligible. Retention of incompletely learned material is sometimes better after a brief interval than it is immediately after practice ceases. This is the phenomenon known as *reminiscence.*

It is doubtful whether a lapse of time, as such, causes forgetting. Experiments on retention after sleep, rest, and interpolated learning of various materials suggest that forgetting is due to retroactive inhibition. This is the obliteration of earlier learning by new activities. The least amount of forgetting occurs after sleep, and the greatest

amount after interpolation of activities similar to those learned, yet different from them as to detail. Emotional upset may also produce retroactive inhibition.

Memory training is successful to the degree that it makes for more efficient learning — it does not develop a "memory" faculty. Some principles of efficient learning which aid retention are: intending to learn, paying close attention, using imagery, associating the new with the old, using rhythm, distributing practice, reciting while learning, resting after something has been learned, and getting a survey of the whole before starting to learn by whole or part methods. Anybody who learns to use these principles will improve his "memory," but whenever he fails to apply them, his "memory" will be no better than it was before.

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10 THINKING

Thought Processes • The Development of Reasoning: Combining past experiences • Multiple Choice: The double-alternation problem • The Reasoning Process: Inferences; direction • Language and Thought • Concepts: Development of concepts; experiments on concept formation; teaching concept formation; concept formation in everyday life • Creative Thinking: Preparation; incubation; inspiration; verification or revision • Thinking and the Brain • Summary

In order to think, one must be able to recall. He must possess and utilize something which *represents* the things of which he thinks — in other words, he must acquire and be able to use symbolic processes or what are frequently called "ideas." The experiments on delayed reaction involve symbolic processes in what is possibly their simplest form. Symbols may be words, images, gestures, or neural or kinesthetic processes which others cannot observe and which the person who has them is unaware of, or unable to describe. Thus, you may think of, or recall something, in terms of your word for it, your image of it, a gesture which represents it, or some less evident substitute, possibly muscle tensions of some kind, which have come to have meaning in terms of your past experience. Kinesthetic imagery has often been suggested as an aspect of thinking. Who has not seemed on the verge of recalling something, yet without any word or clear image of what he seeks? The vague inner tension which appears to exist under such circumstances may well be kinesthetic.

THOUGHT PROCESSES

Thinking is typically a sequential arousal of symbols. We think of one thing; that starts us thinking of another; that of still another, and so on. In this way we manipulate and rearrange, as it were, the various aspects of the world which have fallen within the range of our experience. Except when we "think out loud," this process is carried on implicitly. Words are unspoken and the gestures are so abbreviated as to escape notice. The images and other processes are by their very nature implicit.

In this chapter our chief concern is with the kind of thinking called *reasoning.* Reasoning is differentiated from mere *thinking of* something, because it involves a sequence of symbolic activities. When you *think of* something, you are of course calling up symbols which, like those aroused in the delayed reaction experiments, enable you to respond to absent stimuli. This aspect of the thought processes is synonymous with *recall.*

Reasoning also differs from what has been called *reverie,* or free association of ideas. This is because, in reasoning, recall and the sequence of associations are controlled. In reverie, the associations are random, as they would most likely be if I should ask you to say every word which comes to mind. In reasoning, however, the "associations begin in a problem, and end in its solution." [1] The nature of the problem gives us a directional *set.* It produces selective rather than indiscriminate recall. Suppose instead of asking you to say every word which comes to mind, I should ask you to say the names of ani-

mals. Then you would have an "animal set." Your associations would concern animals, and nothing else. In reasoning, the set comes from the problem. If the problem is how to get our car started, we think of things that might be wrong with the car, not of unrelated things.

Reasoning is differentiated from the type of thinking called *fantasy* by being more realistic than the latter. Typical forms of fantasy are dreaming and daydreaming. Dreaming is often directed toward the solution of a problem — but the solution is usually unrealistic. Sometimes the dream is a symbolic wish-fulfillment, as claimed by Freud. You would, let us say, like to spend a winter in Florida. In the dream you buy your ticket, get on the train, see the landscape passing by, alight at a fashionable seaside resort, and so on, even though there is, in reality, no chance of your being able to make the trip. The dream fulfills your wish, but only symbolically.

Sometimes the dream fantasy looks like an attempt to explain some sort of present stimulation. You dream, for example, that you are hanging by your hands from a skyscraper, you see the street way below with its toy-sized people and vehicles, your fingers are slipping, and you scream for help, perhaps waking yourself. Then you find that you are lying on your back with your arms stretched back in an awkward position, caught under the end of the bed. You are actually in a predicament, but not the predicament symbolically represented. The writer dreamt that he was trying to escape from hell, but woke to find his feet on a hot radiator. The dream fantasy often, so to speak, seeks a way out of difficulties.

Daydreams are essentially like dreams. The fantasy is again unrealistic. If you are not able to meet your financial obligations, for example, you may imagine yourself winning a thousand dollars on a quiz program, digging up buried treasure in your garden, or receiving a legacy from some rich uncle. You may, on the other hand, lay definite plans to solve your problem. You may think of getting a job that pays a larger salary, of selling some of your property, or of doing some extra work in spare hours. If these are realistic solutions — solutions probable of accomplishment — we say that you have been reasoning, rather than that you have been daydreaming.

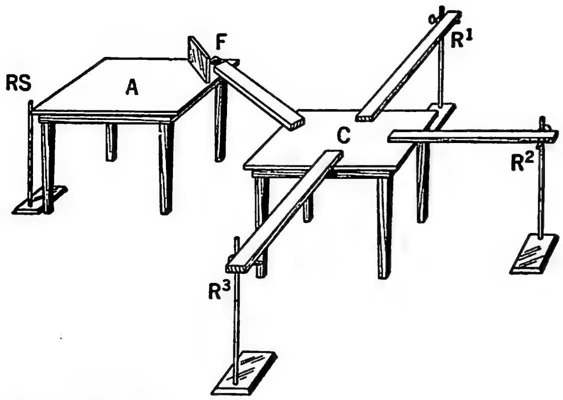
Reasoning first appears in lower animals like the rat. It becomes increasingly evident and complex as the human level is approached. Reasoning at the human level begins in early childhood.

THE DEVELOPMENT OF REASONING

Three tests have been widely used to study reasoning in animals, and all three have been modified for use with human subjects. One of these confronts the organism with a problem that can be solved only by combining previous experiences. Another requires the subject to make a temporally related series of turns, without any external or internal sensory cues to guide it. This is the *double-alternation problem.* Still another test requires that certain relations be discerned by the subject. In a sense, it is a test of generalizing ability. This is the *multiple-choice test.*

Combining past experiences

Looked at from one angle, reasoning is combining past experiences in order to solve a problem which cannot be solved by mere reproduction of earlier solutions. A situation used to test this process in rats is illustrated in Figure 125. The animal is first allowed to explore the entire room, the ringstand (*RS*) and the table (*A*), which is reached by climbing the ringstand. The partition around *F* prevents the rat from reaching this region. Preliminary exploration continues for a few days so that the animal may become familiar with every as-



125

Maier's Reasoning Test for Rats

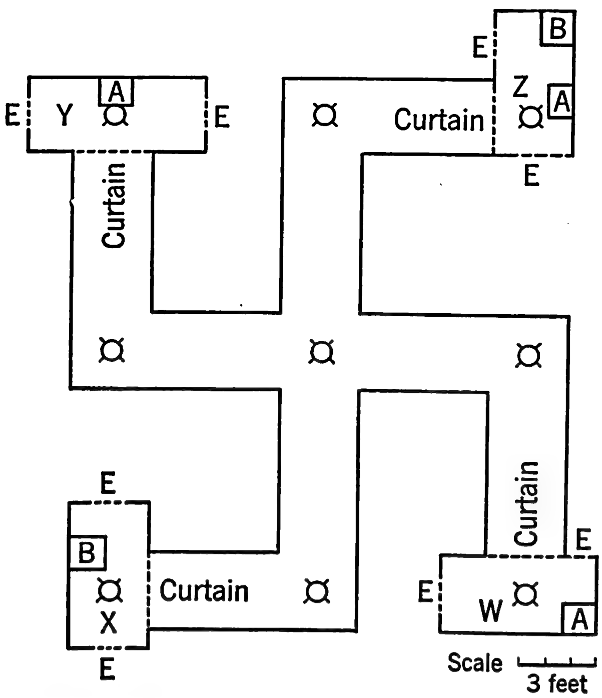
For explanation of this apparatus, see the text. (After Maier, N. R. F., "Reasoning in White Rats." Comp. Psych. Monog., *1929, vol. 6, p. 23.)*

pect of the situation. Table *C* is then added to the room and an elevated pathway is run from it to the blocked-off region (*F*) on table *A*. Three other pathways, each reached by a ringstand (*R* 1, *R* 2, and *R* 3), are connected with the new table, as illustrated. Use of any one of these ringstands and the associated pathway makes it possible for the animal to reach *F*.

Learning to run from any part of the room, up *RS* and onto table *A*, is designated *Experience I*. It does not enable the rat to reach *F*, the place where food will appear in the actual reasoning test. After addition of table *C* and the new ringstands and paths connected with it and with *F*, the animal is trained to climb one of the three ringstands (*R* 1, *R* 2, or *R* 3), and traverse the path which runs from it to *C*, and from *C* to *F*. This is designated *Experience II*. The test of reasoning comes when the rat is placed at *A*. Its problem is to reach the food at *F*. The animal has learned to descend *RS* (part of Experience I), and it has learned to climb, let us say, *R* 2 and proceed from that point to *C*, and then to *F* (Experience II). But the animal has never before descended *RS* and gone to *R* 2. Will it bridge this gap? If it does so without further training, one may say that it has combined the two separate experiences.

The typical reaction in this situation is somewhat as follows: (1) Random activity at the obstruction. (2) Running back and forth between the obstruction and the edge of the table. (3) Descending *RS*. (4) Running across the floor to *R* 2 (or whichever stand has been used for Experience II). (5) Climbing *R* 2 and following the path now available until *F* is reached. Control tests have shown that the animals do not reach the appropriate ringstand by chance, but as a result of previous training with it.[2]

A modification of this type of problem for use with children is shown in Figure 126. The child first explored the apparatus so as to become familiar with its various aspects. There were three parts to the test period. (1) The child was given another brief exploration, then removed via a predetermined booth, designated *Y*. This exploration, and those which preceded it, comprised Experience I. (2) The child was led from the exit, in this case at *Y*, around the outside of the apparatus by a devious route, and finally to another booth, designated *W*. Here there was a toy windmill house. When the child dropped a penny into the chimney of the house, a tune began to play and the windmill began to turn. The experience in this booth was designated Experience II. The experimenter and child then went out, ostensibly to look for a penny with which the child could play the tune again. Finding the penny, the experimenter took the child to still another booth, designated *X*. The child was then told to go and find the windmill. It could not go directly to *W* from *X*, however, unless it combined Experience I (general knowledge of the layout of the apparatus) and Experience II (knowledge of the particular booth in which the windmill appeared). The route from *W* to *X* had not previously been learned, hence



126 **Maier's Reasoning Test for Children**

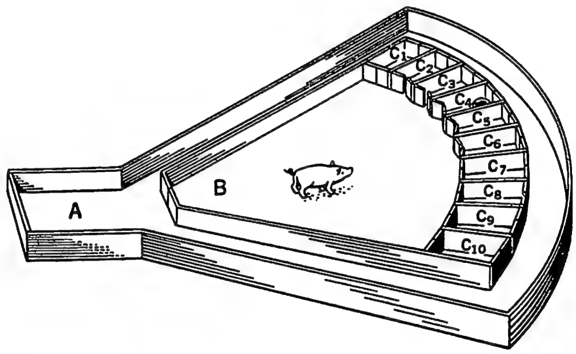
W, X, Y, and Z are booths at the end of pathways arranged in the shape of a swastika; E, entrances and exits, covered with cloth. Curtains also separate paths from booths. A is an adult chair; B is a child's chair. The position of lights is indicated. (From Maier, N. R. F., "Reasoning in Children." J. Comp. Psychol., *1936, vol. 21, p. 356.)*

the ability of the child to "combine or integrate two isolated experiences" was tested. In different tests, combinations like *X–W*, *Y–Z*, and *W–Y* were used.

The child's response indicated reasoning, so long as no incorrect alleys beyond the elbow turn were entered. If the child chose at random after emerging from the booth in which it was placed for the test, its accuracy would be only 33 per cent. It was assumed to have solved the problem if it attained an accuracy of 50 per cent in the last ten tests. Five children averaging four years of age had an average score of only 32 per cent. Only one of them attained a score of 50 per cent. Eleven children averaging five years of age had an average score of 44 per cent, and only three of them reached a score of 50 per cent. The average score of children about five years of age ranged from 59 to 83 per cent, the percentage of correct responses increasing with an increase in age. In this study the highest age level was around eight years.[3]

MULTIPLE CHOICE

In solving multiple-choice problems, the subject must learn that the aspect of the situation associated with success always bears a certain relation to other aspects. Look at Figure 127, a picture of a multiple-choice apparatus used with pigs and other



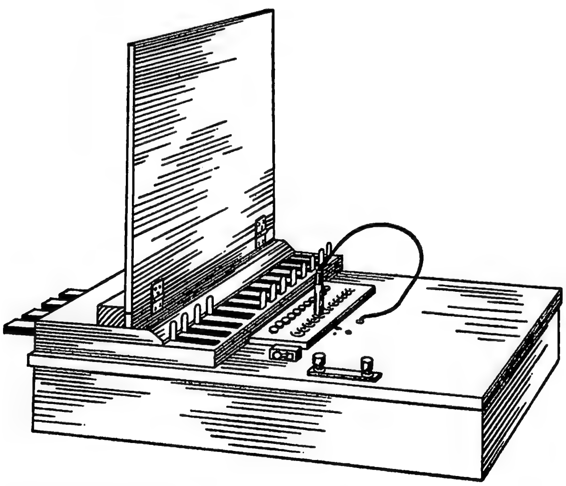
127 **Yerkes Multiple-Choice Problem**

Here doors 2–6 are open and the middle one, door 4, is baited. The other compartments must contain the odor, but not the food, otherwise response to the correct door might be made in terms of odor alone. Some investigators have food at the entrance, rather than in the compartment. Then the animal, after leaving the correct compartment, is allowed to return to A, where he gets a bite of food. This apparatus has been used with rats, monkeys, chimpanzees, and other animals besides the pig. (From Harlow, H. F., "Studying Animal Behavior" in Andrews, T. G. (Editor), Methods of Psychology. *New York: Wiley, 1948, p. 344.)*

animals. There are ten doors confronting the subject, any number of which may be open on a particular trial. Here the relationship to be learned is *middleness.* The animal is required to learn that the middle door is correct, regardless of how many doors are open and regardless of where they are located. In the next setting of the problem, three doors might be open, in the next seven, in the next three, in the next nine and so on.

Instead of using middleness, one may use such relations as the right-hand door, the door to the right of the middle door on one trial and to the left of the middle door on the next, or problems so complicated that even an intelligent human adult could not solve them.

Why do we call these *reasoning* problems? If the correct door were always in a fixed position, for instance, always door 3, the animal would merely have to associate this particular door with food. It might learn the association on a conditioned-response basis, the door serving as a sign for escape and food. In the multiple-choice test, however, the external situation changes from trial to trial. Learning to make a response to a particular door will not do. The subject must somehow combine what it learns in the different settings. It must, so to speak, "put two and two together." The different aspects of previous experience with the problem must be interpreted so that they make evident the general principle.



128 **Yerkes Multiple-Choice Apparatus for Use with Human Subjects**

Four keys are shown projecting toward the subject, who is prevented by a screen from seeing the lights and other mechanisms on the experimenter's side.

Birds, rats, pigs, monkeys, and chimpanzees have all solved certain multiple-choice problems. A problem solved by all these animals is that requiring selection of the end door, either right or left. It may be questioned, however, whether this simple problem requires reasoning. The middle-door problem has been solved by a bird, a monkey, and human subjects. Chimpanzees, who failed the middle-door problem, have solved the end-door problem, the problem requiring response to the right and left door alternately on successive trials, and the second door from the right. So few animals have been used in these investigations, however, that one could not justifiably conclude that birds are brighter than rats or monkeys brighter than chimpanzees. Another chimpanzee, for example, might have solved the middle-door problem, and another monkey might have failed it. The important point is that reasoning problems of this nature are sometimes solved by animals below man.[4]

A multiple-choice apparatus widely used with human subjects is illustrated in Figure 128. Here the subject sits on one side of the apparatus and the experimenter on the other, the two separated by a screen. The experimenter pushes a certain number of keys toward the subject (corresponding to the open doors confronting the animal) and the subject presses the key which he believes to be correct. If the key is correct, a buzzer sounds. Pressure on the incorrect key lights a bulb in a corresponding position behind the screen, thus telling the experimenter

which key has been selected. The subject continues to press keys until the buzzer sounds. Then a new setting is presented. Settings are presented until the subject reacts without error to a predetermined series, or, as usually happens, states the principle involved. The end-key, next-to-the-end-key, and middle-key problems are very quickly solved by human adults, but a problem like that calling for an alternate response to keys on each side of the central one sometimes requires dozens of trials.[5]

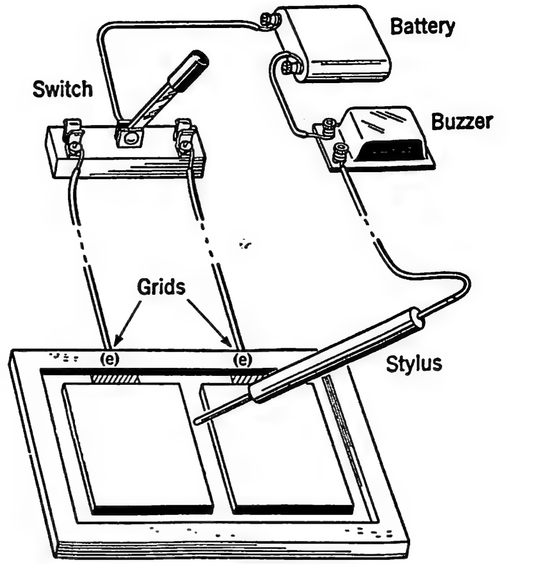
The double-alternation problem

This is another problem which, like that described above, can be used with both animal and human subjects. A stylus form of the apparatus is shown in Figure 129. An open-alley form has been used with animals as well as with human children and adults. The problem is essentially the same, whichever form is used. It is to learn the correct sequence of turns which must be made, following successive trips up the central alley. This sequence, for a series of four successive trips, may be either right, right, left, left (*rrll*) or the reverse. Each correct turn is followed by a reward. Incorrect turns lead to punishment. After making a wrong turn, the subject must retrace until the correct alley is reached. A trial consists of four trips from the entrance, up the central alley, and back again to the starting-point. After the fourth trip, the subject is given a rest.

Observe that the apparatus is bilaterally symmetrical, and that there are no external differential cues to guide the subject. If a red light flashed on whenever a right turn was to be made and a green light whenever a left turn was required, these lights would serve as differential cues. The correct turn would be made in terms of the color of the light at the end of the central alley.

Suppose that no lights were present, but that the right and left turns were made in different places within the apparatus. Then we would have the type of maze already considered. This is sometimes called a *spatial maze,* because the turns differ in space. Differing in space, they provide different visual, auditory, olfactory, tactual, and kinesthetic cues to which the respective turns may become conditioned. Making the correct turns in this type of maze, whatever their sequence, would provide no proof of reasoning. In the *temporal maze* used in reasoning tests, however, each turn occurs in the same place. Moreover, all external conditions are identical, regardless of whether the turn required at any moment is right or left.

But how about kinesthetic cues; those associated with muscle tensions? One might think that these would provide cues for the required turn. If the sequence were *rlrl* in-



129

A Stylus Form of Hunter's Double-Alternation Temporal Maze

The stylus is shown in the central alley near the choice point. As he moves it toward the bifurcation at the top, the subject must decide whether to go to the right or the left. The buzzer sounds whenever he makes the wrong move. For further explanation, see the text.

stead of *rrll*, this might be true. Having turned to the right in one trial might produce muscle tensions which would persist until the animal reached the same point again. These cues might become conditioned to a left turn. Likewise, muscle tensions persisting after the left turn might serve as conditioned stimuli for a right turn. But in the *rrll* sequence, no such guidance is possible. After having turned right the first time, the animal might have muscle tensions which would guide it to the right again. On the third trip, however, the same muscle tensions would have to guide the animal to the left. Muscle tensions from just having gone to the left would then have to guide to the left again. In a continuation of the sequence, the same tensions would have to guide the animal to the right. In other words, the same muscle tensions would at some stages have to guide the animal in one direction and at other stages in another direction. Such a dual guidance by the same stimuli in close temporal succession is impossible. The only satisfactory explanation of *rrll* responses in the temporal maze is that the animal somehow "figures out" the proper sequence.[6]

Human subjects usually formulate this problem verbally. They attack it in an overt trial-and-error fashion at first, but soon begin to test out this or that hypothesis. The correct hypothesis is sometimes hit upon rather suddenly. A subject may seem to be making no progress — then a correct sequence occurs. Following this he says something like "Oh, I get it. You go two times to the right and two times to the left." He often reports that he tried out and tested various other hypotheses before hitting upon the correct one.

White rats, the lowest animals tested with the temporal maze, have not learned the problem in its usual form, even in one thousand trials. But some have learned the solution by other means. They first learned the separate turns in different T-shaped boxes. Then the *rr* sequence was taught in one box and the *ll* sequence in another. Transferred to the temporal maze after such training, a few of the rats eventually learned the *rrll* sequence. When required to continue after the *rrll* series, they responded *lllll*. . . . Rats thus failed to continue the sequence.[7]

Raccoons, on the other hand, have learned the sequence in the temporal maze directly — that is, without preliminary training in other mazes — and have continued the sequence for two additional turns; that is, they have responded *rrllrrrr*. This shows a much better grasp of the problem than occurs in rats. Monkeys have done better still. In a special form of the problem, they have learned an *rrllrrll* sequence, then extended the series to eight additional turns, their total series of responses being *rrllrrllrrllrrll*.[8] Human subjects have learned the double-alternation problem much more readily than animals, and they have extended the series until told to stop. When asked to continue, in other words, they have usually responded *rrllrrllrrllrrll* . . ., perhaps saying "right, right, left, left . . . ," either overtly or implicitly, while doing so.

Young children do not do very well on the double-alternation problem, even when it is presented in the form shown in Figure 130. This apparatus was used, as described in the legend, in an experiment with 31 children ranging in age from two to over six years. Neither in this study nor in an earlier one using a temporal maze, did children below the third year solve the double-alternation problem.[9] Two out of eight three-year-olds learned the problem. The youngest of these was three years and seven months. They required an average of 20 trials. All of eleven four-year-olds learned it. The average number of trials was 16.9. Still fewer trials were required by older children, the five-year-olds averaging 11 and the six-year-olds 6.5 trials. There was a high negative relationship between age and trials required to learn and between intelligence

130

A Double-Alternation Box Apparatus

Here two boxes replace the right and left alleys of the temporal maze. The child's side of the apparatus is shown. Upon being brought into the room for a test, the child was asked, "Would you like to play this game?" He was then allowed to examine the apparatus, opening and closing the lids. Then the experimenter said, "I'll put candy in the boxes." Then, "Shall we begin?" Both hands were put into the boxes, but one left a piece of candy in the correct box. The child opened a box. If it was the correct one, he took out the candy, which he could keep or eat. If he opened the incorrect box, he found it empty. To get the candy he then had to open the correct box. After eight responses, the correct sequence being rrllrrll, *the experimenter said, "Let's stop now." After 15 seconds, the sequence was repeated. With younger children the sequence was sometimes interrupted short of eight responses. The criterion of mastery was three correct successive series of eight responses each, or* rrllrrll, rrllrrll, rrllrrll. *(From Hunter, W. S., and S. C. Bartlett, "Double Alternation in Young Children."* J. Exper. Psychol., *1948, 38, p. 559. Photo courtesy of S. C. Bartlett.)*

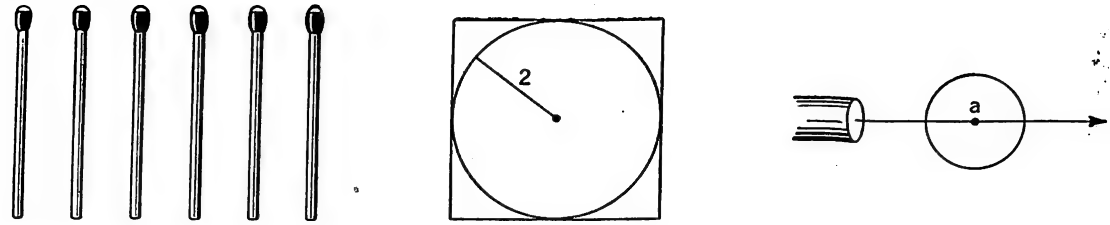
and trials. All children who learned the problem were able to continue the series beyond the original sequence of eight responses. Several subjects talked to themselves or the experimenter while doing the experiment. The youngest to verbalize the problem were five-year-olds. It was stated in various ways. Thus, "It's in there (R) two times and in there (L) two times," "I know how now: two times and two times," or "They go one and then in the same and then in the other." [10]

Normal adults learn double-alternation problems much more readily than children. In one study, the average number of errors per subject for children was 30 as compared with 16 for adults.[11] Adults readily extend the series and verbalize the problem.

THE REASONING PROCESS

Reasoning does not occur unless there is a difficulty, or unless a question has arisen for which there is no ready answer. It is quite possible that the rats and other animals used in our experiments on reasoning reasoned then for the first time in their lives. It is quite possible, too, that they never again reasoned after psychologists finished the experiment. In order to induce these organisms to reason, it was necessary to confront them with problems which could not be solved by mere reproduction of former solutions, by conditioning, or by overt trial-and-error.

In man, also, reasoning is only initiated by situations which cannot be met in a routine manner. We may go for hours or even days without reasoning, especially if our work is so routine that habitual modes of response enable us to meet, in a more or less automatic manner, every situation that arises. As soon as habitual modes of response fail, however, reasoning is likely to begin. Some problems of everyday life which initiate reasoning are how to get certain things done, how to make something go that has stopped, how to get food, how to pay our bills, how to get where we want to go, and how to avoid distressing situations. Being human, we also express curiosity about aspects of the world. We want to know what certain things are for, and why certain events occur. An average child of three



A B C

131

Some Reasoning Problems

A. Problem: to make four equilateral triangles. B. Problem: to find the area of the square. C. Given: an inoperable stomach tumor situated at a, *and rays which destroy organic tissue at sufficient intensity. Problem: how to destroy the tumor with these rays, yet without injuring the surrounding healthy tissues. (After Duncker.)*

years is already puzzled by objects, situations, and events not directly related to its personal adjustments.

It is interesting to observe, moreover, that what is a problem for the scientist or scientifically minded child or adult may go unnoticed by the general run of human beings. John Dewey, the philosopher, tells, for example, of his concern over why bubbles form on the outside of inverted tumblers that have been washed in soapsuds, and then go inside the tumblers.

The presence of bubbles suggests air, which I note must come from within the tumbler. I see that the soapy water on the plate prevents escape of air save as it may be caught in bubbles. But why should air leave the tumbler? There was no substance entering to force it out. It must have expanded. It expands by increase of heat or by decrease of pressure, or of both. Could the air have become heated after the tumbler was taken from the hot suds? Clearly not the air that was already entangled in the water. If heated air was the cause, cold air must have entered in transferring the tumblers from the suds to the plate. I test to see if this supposition is true by taking several more tumblers out. Some I shake so as to make sure of entrapping cold air in them. Some I take out, holding mouth downward in order to prevent cold air from entering. Bubbles appear on the outside of every one of the former and on none of the latter. I must be right in my inference. Air from the outside must have been expanded by the heat of the tumbler, which explains the appearance of the bubbles on the outside.

But why do they then go inside? Cold contracts. The tumbler cooled and also the air inside. Tension was removed, and hence bubbles appeared inside. To be sure of this, I test by placing a cup of ice on the tumbler while the bubbles are still forming outside. They soon reverse.[12]

In Figure 131 are shown three problems which psychologists have used to study reasoning in children and adults. Solve them, noting at the same time, if you can, how the solution was reached. Then check your answers by referring to page 609. Certain of these problems will receive further consideration in the ensuing discussions.

Inferences

You will doubtless have noticed that, once the problem was given, and you accepted the task of solving it, suggestions began to occur to you. These are known as *inferences* or *hypotheses*. Quite often they occur as questions. You say, "Must the whole match be used for the side of a triangle?" "Will it work if I cross the matches?" And so on.

Let us illustrate from a problem of every-

day life. Suppose that your car stops all of a sudden without apparent cause. You ask, "What's the matter?" "Could it be that I have run out of gas?" You may check the truth of the inference that you have run out of gas by looking at your gas indicator or, if you don't trust that, by examining the gas tank. These are what we might call *explicit* methods of testing your inferences, but you might test it *implicitly* by recalling that you filled the tank only yesterday, that you have traveled so many miles since then, and that it could or could not be empty — unless the gas tank has sprung a leak or someone has syphoned off some gasoline. Failing to find the tank empty, you get another suggestion or make another inference. "Is the gas line choked?" You then check that possibility. So one inference after another occurs to you until, providing you do not run out of relevant inferences beforehand, one of them is found correct. If your knowledge of automobile motors is limited, you may run out of inferences very soon. You must then call in an expert, one who has many more symbolic representations of motors and things that might go wrong with them than you have.

Inferences involve recall of past experience. They are always limited by what one already knows about the situation involved. The more facts he can recall about the situation, the more inferences he is likely to make and the better these inferences are likely to be. The bubble problem mentioned above would not even occur to the average housemaid, but if it did, she could not begin to make relevant inferences.

Those who claim that education should teach people to think rather than cram facts into their heads often overlook the dependence of thinking upon facts with which to think. We should be taught facts, especially those that are relevant to situations which we are likely to meet, and we should also be taught to think more efficiently.

Inferences are usually evaluated before being accepted or rejected. Dewey calls this the *rational elaboration of ideas.* We may accept the first inference that comes to us or we may bring relevant knowledge to bear upon it. Evaluating an inference in the light of other knowledge at our disposal sometimes leads to rejection, then to making a further inference. Thus, we realize that, in terms of how much gas we had in our tank yesterday and the number of miles we have traveled, our gas could not have been used up. Then we think of other possibilities.

Sometimes an objective test of our inferences is necessary. Our critical evaluation of an inference, like that of the empty gas tank, for example, may convince us of its correctness. In many instances, however, and especially in scientific reasoning, it is necessary to prove the correctness of an inference by objective or experimental means. Thus, Dewey could not be certain that his inferences about the bubbles were correct until he arranged an experiment which corroborated them. It often happens that inferences generally accepted as reasonable are found to be false when tested experimentally.

Direction

Recall in reasoning is, as we have already seen, directed rather than random. The nature of the problem, as one conceives it, gives a more or less definite trend to what is recalled. If our car has stopped running, we recall things about cars. Our inferences concern cars and what we know can happen to cars. If some natural phenomenon like the behavior of bubbles at the bottoms of upturned washed glasses bothers us, our recall is of bubbles and things related to them. We are not likely to recall things that are completely irrelevant. The inferences that we make are related more or less closely to the problem as we conceive it.

It often happens, however, that our inferences, while generally bearing on the prob-

lem, follow an inadequate direction in other respects. There are many examples of this in everyday life. A man in his early forties, say, begins to have dizzy spells and jumps to the conclusion that his heart has gone bad. He begins to think of cleaning up his affairs in case he should drop dead. He limits his exercise and his eating. Finally, he convinces himself, or someone else convinces him, that he should have a physical examination. The doctor finds nothing wrong with his heart, but asks some questions about his eyes. Then the patient recalls for the first time that he finds it easier to read if he holds the paper at arm's length, that he experiences difficulty in reading small print on labels, and that his dizziness comes when he suddenly looks from a near to a more distant object, or vice versa. None of these things occurred to him before because the idea that there must be something wrong with his heart sent him thinking in the wrong direction. A checkup with the oculist shows that the patient needs bifocals in place of his present glasses. He makes the substitution and his dizziness eventually disappears.

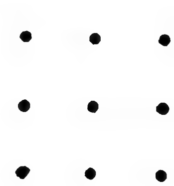
Delusions and direction. Certain delusions of the mentally ill are attributable to reasoning in wrong directions. In so-called "monomaniacs," for example, the direction of associative processes gives bizarre interpretations to the most innocent events.

Has she a tired look? — it is proof of adultery; a gay manner? — she comes from a rendezvous. A look, a movement of the eyebrows, lips, or fingers are so many telltale signs; the same with smiles or tears. Should she utter the name of the supposed lover, the sound of her voice leaves no doubt; should she repeat it often, it is to "accustom herself to hear it in public without blushing"; if she ceases to mention him, the motive can be guessed. In the street, the jealous man thinks that the passers-by are laughing at him; ceaseless allusions are made to his misfortune; he is taken for a complaisant husband. His wife's footsteps on the parquet floor are so many signals to her lovers and compose a telegraphic alphabet that he can successfully interpret. . . .

Mme. X . . . studies minutely the letters that she receives. Punctuation marks or spelling mistakes give rise to numerous interpretations. Her father writes to her: "We desire your cure." She observes that the stop is of an unusual size; it must read: "We desire your cure to stop." (Nous ne désirons *point* ta guérison.) Another woman imagines that her husband is announcing the intention of leaving her by putting two five-centime stamps on a letter instead of a ten-centime one. A look, a smile, a gesture, the shouts and songs of children, the coughing or spitting of a neighbor, the whispers of passers-by, pieces of paper found in the street, a door opened or closed, a mere nothing, serves as a pretext.[13]

Direction in problem solving. The disadvantage of getting the wrong direction and the advantage of getting the right direction in problem solving has been investigated in the laboratory. How the wrong direction or wrong set may interfere with solution is illustrated by the problem indicated in Figure 132. One is required to connect the nine dots by drawing four straight lines without taking the pencil off the paper and without retracing.

In attempting to solve this problem, you make one inference after another, and all are relevant in that they concern the nine dots and the instructions. Any inference which concerns the nine dots, but fails to conform with the instructions, is rejected almost as soon as suggested. You have a set.



132

The Nine-Dot Problem

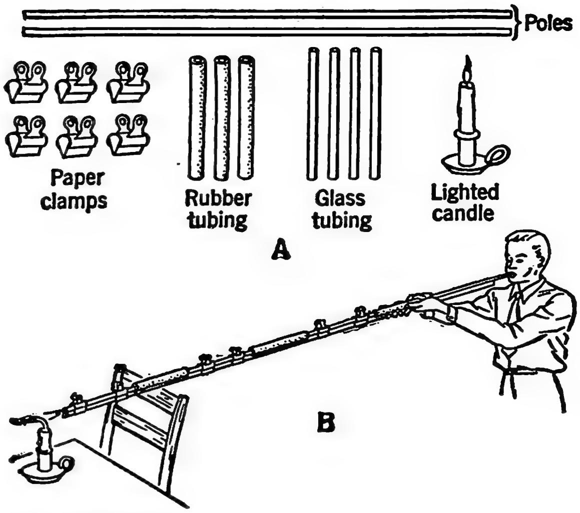
in other words, that is related to the dots and to the instructions. But you may also have a set not involved in the instructions — that is the set which makes you keep all lines within the limits of the area bordered by the dots. As long as your thinking follows this direction, you cannot solve the problem. Every inference will prove inadequate. But when you think of the possibility that lines may go outside of the area within the dots, you have the right direction. The solution may still be far off, but at least you will make inferences more in keeping with the requirements of solution. Eventually, you may hit upon the solution illustrated on page 609.

Following a certain line of thought to the exclusion of others, as in the above example, often seriously interferes with problem solution. The importance of shifting direction is illustrated by an experiment with college students.

One of the problems used in this study called for blowing out a lighted candle from a distance of eight feet with nothing but the materials illustrated in part A of Figure 133. A group consisting of 206 students worked without any suggestion from the experimenter that they should vary their mode of attack. Forty-eight per cent of this group solved the problem within the time allowed. Another group consisting of 178 students was given a preliminary lecture covering twenty minutes in which the following advice was given and elaborated:

1. Locate a difficulty and try to overcome it. If you fail, get it completely out of your mind and seek an entirely different difficulty.
2. Do not be a creature of habit and stay in a rut. Keep your mind open for new meanings.
3. The solution-pattern appears suddenly. You cannot force it. Keep your mind open for new combinations and do not waste time on unsuccessful efforts.

The problem was solved within the time limit by 68 per cent of this group — 20 per cent more than in the group that received no instructions about changing direction.



133

Maier's Candle-Blowing Problem

Problem: Given the above poles, clamps, and tubes, blow out the candle from a distance of eight feet. (From Crafts, et al., Recent Experiments in Psychology. *New York: McGraw-Hill, 1938, p. 354.)*

In a check experiment, 169 subjects attacked two problems of equal difficulty, one before and one after receiving the above instructions. Here the effect of instructions about changing direction doubled the number of individuals achieving a solution.[14]

One difficulty in getting the proper direction is an inability to *reconstruct* the situation implicitly. Take, for example, the problem of the area of the square (p. 236). If this problem is completely novel, we must implicitly move the radius until it touches an edge. If we do this, the answer occurs in a flash. We see that the radius of the circle is one half of the side of the square. The match problem is solved, or well on the way to being solved, as soon as we implicitly place the matches into a tridimensional figure.

Professor Wertheimer studied thinking in children, observing them under various

kinds of classroom instruction. What impressed him was the routine or "blind" nature of much that is taught, and the inflexibility of much of the thinking that results. He decries the "emphasis on mechanical drill, on 'instantaneous response,' on developing blind, piecemeal habits." "Repetition," he says, "is useful, but continuous use of mechanical repetition also has harmful effects. It is dangerous because it induces habits of sheer mechanized action, blindness, tendencies to perform slavishly instead of thinking, instead of facing a problem freely." [15]

What Wertheimer is arguing for is the sort of thing stressed in the above experiments on direction in thinking — that is, to look at a problem in different ways, to seek new meanings, and to look for new combinations. The case of Gauss, the great mathematician, is cited by Wertheimer to illustrate the value of flexibility in thinking.

When Gauss was six years old his school teacher gave the class a problem in arithmetic, asking, "Which of you will be first to get the sum of $1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 + 10$?" Shortly afterwards, while the others were still busy figuring out the answer, Gauss raised his hand and said, "Here it is." Members of the class were doubtless saying "1 plus 2 is 3, and 3 is 6, and 4 more is 10," or something like this. Surprised by the child's quick answer, the teacher is reputed to have said, "How the devil did you get it so quickly?" We know the method that Gauss used (indeed he had hit upon the gist of a very important mathematical theorem) but we do not know exactly what he replied. According to Wertheimer, from whom the above has been paraphrased, Gauss probably said something like this: "Had I done it by adding 1 and 2, then 3 to the sum, then 4 to the new result, and so on, it would have taken very long; and trying to do it quickly, I would likely have made mistakes. But you see, 1 and 10 make 11, 2 and 9 are again — must be — 11! And so on! There are 5 such pairs, 5 times 11 makes 55." [16] The theorem is sum $= (n + 1)\frac{n}{2}$, and it of course applies as well for odd as for even numbered series.

How to achieve such flexibility of thinking is the problem. It occurs readily enough in a genius, who has the relevant information. But what about the rest of us? Such flexibility requires teaching for understanding, or insight at the same time that necessary drill is given. Several investigations have shown that this is possible in the schoolroom, even among children who are not of the mental calibre of Gauss.[17]

LANGUAGE AND THOUGHT

The view has often been expressed that thinking is "restrained speaking," "subvocal talking," or "implicit language activity." Reasoning can, however, occur without language. This is illustrated by experiments on animals.

Even where language does exist, a certain amount of thinking is probably non-linguistic. We may, for example, think about things for which we do not have names. In such instances we often have a visual or some other image of the thing thought about. Some psychologists have claimed that thinking can occur without involving either words or images.

After recognizing these limitations on the view that thinking is merely implicit language activity, we must admit that the symbols which represent most of the world are language symbols (verbal, gestural, or written), and that most of our thinking appears to be an internal manipulation of such symbols.

That thinking is closely tied up with inner speech is suggested by attempts to analyze thought processes. Try to analyze your everyday thinking and you will find that words are everywhere evident. It usually appears that, in thinking, you are talking to

yourself. Children often do their thinking out loud for everyone to hear it — until they learn that it is customary, and often worthwhile, to keep one's thoughts to oneself. The deaf and dumb, who have previously learned the sign language, have been observed to move their fingers while thinking, much as they move them while talking, only to an abbreviated degree. Hand movements made in writing, and even eye movements made in reading, may accompany thought processes. Electrical potentials picked up from the tongue and throat during silent counting and thinking show that abbreviated movements of these speech mechanisms are present.[18]

CONCEPTS

A concept is a process which represents the similarities in otherwise diverse objects, situations, or events. Concepts are products of reasoning and, once developed, play an important role in further thinking. A large proportion of the words in any complex language represent concepts. Words such as "tree," "dog," "liquid," "beauty," and thousands of others in our language, represent common aspects of things that are in many respects quite different one from the other.

In a sense, concepts are condensations of past experience. They bring together in a single idea, so to speak, what has been learned about properties of many different things. Take, for example, the concept *tree*. This concept is foreign to certain Australian tribes. The native speaks of particular objects, like the jarrah, the mulga, and the gum, but he has no word to represent what is common to them all. So he has no concept "tree" such as is represented by the word "tree" in our language. The child would be in a similar fix if it spoke of the chow, the spaniel, and the St. Bernard, but had not acquired the concept *dog*.

Development of concepts

The development of concepts requires two processes known respectively as *abstracting* and *generalizing*. Sometimes the two cannot be separated clearly, but each of them is at least implied whenever a concept is formed.

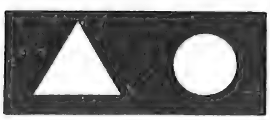
Abstracting is observing the similarity of otherwise different things. The individuals who first invented the concept *tree* must have observed that trees, regardless of how much they differ, still have something in common. Likewise, the child, in acquiring the concept *tree*, or understanding the word "tree," must make similar observations. The child's first experience with a tree may be with a magnolia, with which it hears the word "tree" associated. But later on, the child hears the same word attached to the pine, an object of quite different appearance. Later still, it hears the oak called a tree. After a series of such experiences with a variety of trees, the child may see, let us say, a willow which has never before been called a tree in its presence. If it designates this a tree, the child must have observed something of what the willow has in common with other trees. But it must also have put aspects of previous experiences together with the present experience and reached the conclusion that this, being like the others in certain respects, is to be designated in the same manner. Deriving a principle from varied experiences in this way is generalizing. One might abstract but fail to generalize, but one could not achieve an adequate generalization, or concept, without first abstracting.

One should not gather the impression, from what we have just said, that the processes of abstracting and generalizing are necessarily deliberate, or even carried on consciously. In animals and human infants, our only evidence of abstraction and generalization comes from observation of similar reactions to different situations having a common characteristic. Looking at it from another angle, all we know is that different situations are equivalent from the standpoint of the reactions aroused and that this equiv-

alence depends upon something which, despite their diversity, these situations have in common. We do not know whether the subjects deliberately analyze the situations, and whether they are conscious of similarities and relations.

Experiments on concept formation

Concepts have been developed, under experimental conditions, in a variety of organisms ranging from rats to men. A typical procedure with animals and infants is as follows: The subject is confronted with two forms and required to discriminate between them. These may, for example, be a triangle and a circle, as illustrated in Figure 134. Using a discrimination procedure (p. 137) a response to the triangle is rewarded and a response to the circle either not rewarded or punished. One will recall, from our previous discussion, that the stimuli are switched from side to side in a chance order so that the problem may be solved only by discriminating the visual stimuli. After the triangle is being selected with an accuracy of around 100 per cent, a square, or some other figure, is substituted for the circle. This is to discover if the subject is responding negatively to the circle or positively to the triangle. Continued correct performance indicates the latter. Usually, the subject continues to select the triangle. We then replace the circle and *invert* the triangle. When we do this most animals respond as if confronted by a new problem. Accuracy of response drops from around 100 to around 50 per cent. It is apparent, in such instances, that what was being discriminated was a particular pattern of black and white, not a triangle *per se*. Monkeys and children have continued to select the inverted triangle. For these subjects, the inverted triangle and the original one were apparently equivalent. The subjects must have reacted in terms of triangularity, three-sidedness, or some other abstracted property which triangles have regardless of their position. Animals which fail to make this transition abruptly may be trained to respond to properties which otherwise dissimilar triangles possess. In one study, rats learned to respond to a large variety of triangles (small, large, upright, inverted, apex to right, apex to left) as equivalent, but over 1,000 trials, with frequent substitutions of triangles and further training, were required. In each trial the only constant aspect of the positive situation was the presence of some sort of triangle. All other concomitants varied. Finally some animals responded positively to triangles still different from those involved in training. They made a transfer, for example, to right-angled, equilateral, and outlined triangles. In other words, they had learned to abstract triangularity, the only characteristic involved in all of the different kinds of triangles. The abstracted characteristic may have been three-corneredness, three-sidedness, or the like.[19]

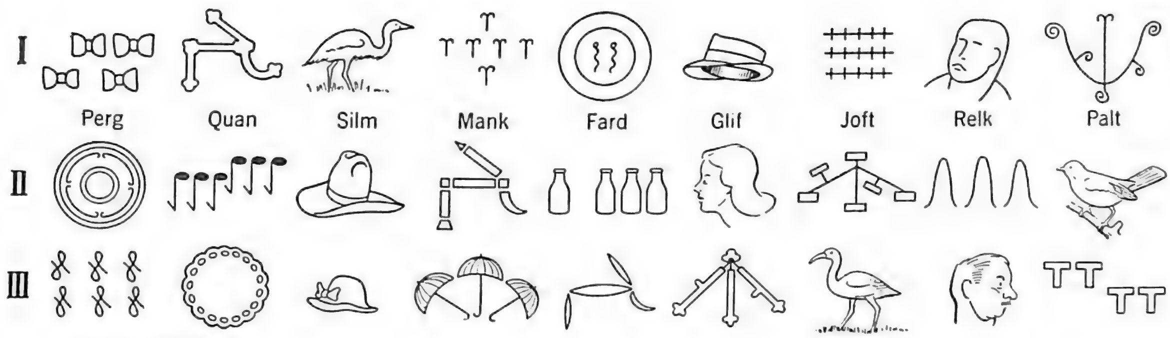


134

Concept Formation

These are two stimuli between which the subject is required to discriminate in experiments on concept formation. The triangle is eventually inverted.

Problems similar to the one just described are too elementary for use with older children and adults. A more complicated problem on concept formation is that illustrated in Figure 135. Using an exposure apparatus to present one picture at a time, the experimenter asked the subject to name the picture as it occurred. Each picture had a nonsense name, as illustrated, but all figures possessing a common characteristic had the same name. For example, the pictures in the first row had, respectively, the following names: *Perg, Quan, Silm, Mank, Fard, Glif,*



135

Materials Used for Heidbreder's Experiment on Concept Formation

The terms Perg, Quan, *etc., represent concepts rather than particular pictures. What is* Perg *in the second line? In the third line? (After Heidbreder, E., "The Attainment of Concepts: I. Terminology and Methodology."* J. Psychol., *1947, 24, p. 95.)*

Joft, Relk, Palt. Look at the first picture in the second series. What is its name? Its name is *Fard.*

The subjects of course saw only one figure at a time and none were labelled. Moreover, they thought that the experiment was on memory. Their initial set, at least, was to memorize, not to abstract and generalize. Whenever the subject failed to respond in time, or said the wrong name, he was prompted. The experiment continued until each picture in 16 strips like those illustrated was correctly named. With the material illustrated, you can test yourself on abstracting the common features of all the *Fards,* all the *Pergs* and so on. The outcomes of a long series of experiments using this type of material need not concern us here.[20]

A different test of concept formation utilizes the objects shown in Figure 136. Confronted with these items, the subject is asked to select any item, then place with it all of the articles he thinks belong with it. He may be asked to group articles with one that the examiner selects, or to group *all* articles which belong together. When the test is used in clinical psychology for diagnostic purposes, the patient is asked to arrange new groupings and also to say why the objects in a grouping arranged by the examiner belong together. Some of the most frequent bases of grouping are: *use* (tools,

136

A Test of Abstract and Concrete Thinking

This is the male form of the Gelb, Goldstein, Weigl, Scheerer (G.G.S.W.) Object Sorting Test. (From Goldstein, K., and M. Scheerer, "Abstract and Concrete Behavior: An Experimental Study with Special Tests." Psychol. Monog., *1941, 53, p. 80.)*

eating utensils, edibles), *situation* (dinner setting, tools in a tool box), *color* (silver, brown, white), *form* (oblong, round), *double occurrence* (pairs — two lumps of sugar, two forks), and *material* (wood, metal).[21]

One can recognize immediately that this is a test of concepts, for what the subject is required to do is to group different things which have some common attribute. Children, schizophrenics, and patients with brain injuries tend to group the objects on a very *concrete* basis, such as the reds together or matches and candle together. Normal adults group on the basis of concrete aspects, but they are able to transcend the obvious similarities or associations and group on the basis of such abstract relations as "tools," "pleasure-giving objects," and so on. When an individual assumes this conceptual approach "the presented articles are not taken as *individual* things, but as representative of a category. The subject deliberately disregards, abstracts from, the concrete singularity of the presented article."[22]

Teaching concept formation

Some investigators have sought to facilitate concept formation by discovering the best methods of teaching individuals to proceed from the concrete to the abstract. In one such study, Chinese characters were used. These lend themselves to such research because each written word has within it a symbol which gives the "essence" of what it refers to. Thus several words that are in most respects quite different all have a common symbol which represents something which all have in common. For example, the symbol 木 is the word for wood. The following are the words for, respectively, table, bed, frame, tree, and forest: 檯 牀 架 樹 林. All are wood, so the symbol 木 appears in every word. Likewise the symbol for soil 土 appears in the words for land 地, grave 墳, dust 塵, and ditch 壕.

In the research on facilitation of concept formation, college students were shown Chinese characters like the above and, two and one-half seconds after each character was presented, a nonsense sound representing the characteristic which it had in common with certain others in the series was also presented. Thus all having the element 氵 were *oo*, all having the element 歹 were *yer*, and so on. Characters having the common element were mixed with others having a different common element.

The subjects were not told that they were doing an experiment on concept formation, abstracting, or generalizing. Until they learned otherwise as a result of their experience, all thought that they were doing a memory experiment. They were merely asked to name the element (*oo*, *yer*, etc.) as the complex Chinese character containing it was presented.

Eventually it "dawned" on most of the subjects that the different *oo* characters, for example, were linked by a common factor — the 氵 embedded in each of the Chinese characters. The investigator says that "individual concepts usually came into consciousness very gradually. Erroneous first impressions were either discarded or transmuted into the correct form by a continuous development. Trial and error plays, if not a dominating, at least a very great rôle in the process."[23]

Various training procedures were used with different groups and each varied from the others in the readiness with which it produced conceptual responses. There was no difference in the efficiency of starting with simple characters and going to complex ones, on the one hand, and starting with complex characters and going to simple ones on the other. Nor was there any advantage to teaching the concepts out of their context — that is, by presenting the naked common elements. In identification with new complete Chinese characters, the individuals who had the concepts given them in naked form had

to learn to discriminate them from the whole character. In this test, which is the sort of thing required in everyday life, neither those who had the concepts given them nor those who evolved them through trial-and-error learning had an advantage. A combination method in which naked characteristics were given, mixed in with the series of complete characters, was better than any other mentioned above. The most efficient method of all, as one might imagine, was to present the entire character, but with the common element redrawn in red so that it stood out or attracted attention.

Regardless of the precise method used, it is essential that the principle of dissociation by varying concomitants be followed if an adequate concept is to develop. This principle has been stated as follows: "What is associated now with one thing and now with another tends to become dissociated from either, and to grow into an object of abstract contemplation."[24]

In other words, if the concept of triangularity is to develop, the triangularity must appear in different particular situations; if the concept *oo* is to develop, the character  must appear now in one context and now in another; if the child is to develop an adequate concept *dog*, the word *dog* must be associated with white creatures, black ones, brown ones, large ones, small ones, smooth ones, rough ones, and so forth. The concept would never develop so long as only one dog, or one type of dog, was associated with the term *dog*.

Concept formation in everyday life

Many situations in everyday life do not involve such obvious common elements as those of the above experiment. Human beings not only acquire concepts by observing common elements and figuring out relationships, but they learn them by asking questions about things which puzzle them and getting answers in return. The child hears his parents talking about having time to do a certain chore, about its being time to go to bed, about something happening in time, and so on. Puzzled, he asks what time is. His parents may have great difficulty in explaining time, but what they tell the child leads to formation of a concept of *time*, adequate or inadequate. Take the concept *life*, as a further example. This may have both an observational basis and a basis in interrogation of elders. The child observes dead and living animals, and he observes, perhaps, that the living ones move and the dead ones do not. But concepts of *life* and *death* on this basis alone are likely to be far from adequate. Upon helping to bury the dead animal, the child may ask, "When is he going to wake up?" "Does he like being down there?" or, "How is he going to get out?" You then realize how limited the child's concept really is. You perhaps explain that animals once dead never wake up, and that they do not know anything, so can neither like nor dislike being buried. This process of observing, questioning, and getting answers goes on for years before the child has concepts of life and death which come close to those held by adults.

One method of finding out what concepts children already have is that of questioning them. Several investigators have used this method to discover how particular concepts develop with age and experience. The child is asked, for example, "Do you know what it is to be alive?" A reply to this question brings further questions.

Thus, a boy of eight years was asked, "Is the sun alive?" to which he answered, "Yes." Asked, "Why?" he replied: "It gives light. It is alive when it is giving light, but it isn't alive when it is not giving light." Asked, "Is a bicycle alive?" the child replied: "No, when it doesn't go, it isn't alive. When it goes, it is alive." To the question, "Is a mountain alive?" the child answered, "No."

The query, "Why not?" brought the reply, "Because it doesn't do anything." It is obvious that for this child the concept *life* means ability to move or do something. By way of comparison, let us take the more mature concept of a twelve-year-old boy similarly questioned. The boy said that he knew what it meant to be alive. He was then asked, "Is a fly alive?" He said, "Yes," and, upon being asked, "Why?" replied, "If it wasn't alive, it couldn't fly." To the question, "Is a bicycle alive?" the boy replied, "No." "Why not?" brought the reply, "Because it is we who make it go." Further questioning verified the fact that this boy attributed life to anything that could move of its own volition.[25]

As children grow older, their concepts gradually come closer to those of the adults with whom they associate. Adult concepts are themselves inadequate, sometimes childish, as compared with those of other adults. Many an intelligent adult, even, would have difficulty in defining *life* in a manner which biologists would accept as adequate. But, inadequate as they may be, our concepts give us an advantage which would be lost were we compelled to speak and think about particulars only.

CREATIVE THINKING

Many of man's creative works develop gradually, as if by a process of trial-and-error. One of the first attempts at developing a locomotive, for example, was a boatlike structure with a sail and wheels which ran on tracks. Next, a horse running on a treadmill was used for motive power. Then, a horse pulled the carriages along tracks. The steam-driven vehicle which followed had many obvious defects — it was so uncertain in action, actually, that a horse-drawn "train" raced it. There were then gradual refinements of locomotives, leading up to our present streamliners. Despite the obvious trial-and-error progress here represented, there were many inspirations which made successive steps in the development of the locomotive possible. And so it is with all creative work. There is an evident need to produce something different, then attempts to produce it, followed, quite often, by insignificant insights.

In recent years, several psychologists, political theorists, artists, inventors, and other creative thinkers have either analyzed their own thinking or had the products of their thought analyzed by others in an attempt to discover something of the creative process. It is rather generally agreed, as a result of these studies, that creative thinking has three, and often four, more or less definite stages. These are: (1) *preparation,* (2) *incubation,* (3) *inspiration* or *illumination,* and (4) *verification* or *revision.*[26] Henri Poincaré, the great French mathematician, who also wrote about the process of creative thinking, experienced these stages. In Figure 137 he is pictured solving a mathematical problem.

Preparation

All education is, of course, a preparation for creative thinking, although we may not use its products creatively. Specialized education, like training in medicine, is preparation for creative thinking along special lines. The doctor's education gives him the information (symbolic processes) which prepares him for possible creative thinking in medicine. The inventor of electrical devices must have preparation along electrical lines. Einstein's concept of relativity would never have occurred to him had he not first learned the calculus.

In addition to this general preparation for possible creative thinking, one needs specific preparation for specific problems. Thus, a doctor confronted by some especially difficult medical problem may have to consult other authorities about various aspects of the general problem before being able to reach a conclusion concerning it. Even in

137

The Four Stages of Creative Thought

These drawings illustrate what is described by Poincaré as follows:

"For fifteen days I strove to prove that there could not be any functions like those I have since called Fuchsian functions. I was then very ignorant; every day I seated myself at my work table, stayed an hour or two, tried a great number of combinations and reached no results. One evening, contrary to my custom, I drank black coffee and could not sleep. Ideas rose in crowds; I felt them collide until pairs interlocked, so to speak, making a stable combination. By the next morning I had established the existence of a class of Fuchsian functions, those which come from the hypergeometric series; I had only to write out the results, which took but a few hours.

"Then I wanted to represent these functions by the quotient of two series; this idea was perfectly conscious and deliberate, the analogy with elliptic functions guided me. I asked myself what properties these series must have if they existed, and I succeeded without difficulty in forming the series I have called theta-Fuchsian.

"Just at this time I left Caen, where I was then living, to go on a geologic excursion under the auspices of the school of mines. The changes of travel made me forget my mathematical work. Having reached Coutances, we entered an omnibus to go some place or other. At the moment when I put my foot on the step the idea came to me, without anything in my former thoughts seeming to have paved the way for it, that the transformations I had used to define the Fuchsian functions were identical with those of non-Euclidean geometry. I did not verify the idea; I should not have had time, as, upon taking my seat in the omnibus, I went on with a conversation already commenced, but I felt a perfect certainty. On my return to Caen, for conscience' sake I verified the result at my leisure."

(From Poincaré, H., "Mathematical Creation" as edited and presented by J. R. Newman in *Scientific American*, August, 1948, pp. 56–57. Drawings by Stanley Meltzoff.)

preparing a term paper, which may at times be a creative activity, you must first acquaint yourself with relevant facts concerning the topic about which you are to write. A comparable "soaking-up" of facts is the required preparation for any creative work.

Preparation for creative thinking often includes attempts to relate facts in various ways. There is much trial and error. Perhaps there is pacing of the floor or biting of fingernails. You attempt to write your term paper; you may write something; tear up what you have written; and start over again, only to tear that up in disgust. Edison remarked that much of his inspiration was actually perspiration, referring, perhaps, to this sort of preparational activity.

Incubation

This stage of creative thinking is characterized by absence of overt activity, or in many instances even of thinking about the problem. Sometimes, however, certain ideas concerning the problem recur. Poets and artists report the following details about their incubation periods:

> The idea smoulders in my mind until completed.
>
> I have an idea in the back of my mind for a long time, sometimes a week or two. I don't think constantly about it, but it keeps coming back.
>
> I often carry an idea around for several weeks before I make a picture, though sometimes longer. I got ideas in Santa Fe last summer to do now. The ideas recur from time to time while I am occupied with other things.[27]

This is a period of no obvious progress. Some creative thinkers intentionally put all thoughts of their problem in the background after preparing themselves. Some go for a stroll, read light literature, engage in a game of golf, or perhaps have a sleep.

The stage which follows incubation has led some to assume that, while the creative thinker turns his attention elsewhere, his problem is being solved unconsciously. This would be difficult, if not impossible, either to prove or disprove. It is likely that associational activities initiated by attempts to solve the problem continue to some degree. We see some evidences of this in connection with dreams. The individual may give up his problem and go to bed, only to have aspects of it appear in his sleep. There is no reason to believe otherwise than that the associational processes would continue in a similar manner were he to remain awake and engage in other activities. This continuance of associational activities, once started, has already been referred to as *perseveration.*

Inspiration

Most creative thinkers claim that their creative ideas, following the period of incubation, come to them suddenly. The significant ideas may occur at any time, sometimes even while the thinker is dreaming.

In writing your creative theme, you have doubtless been discouraged by an evident lack of progress, when suddenly the material seemed to organize itself, the relevant ideas came copiously and rapidly, and what had been obscure became clear. One will recognize that this process resembles the process of insight during other forms of learning activity. It is often, as in those instances, preceded by a certain amount of trial and error.

Trial-and-error activity, however, is usually considered part of the preparation rather than the incubation stage of creative thinking. Several creative thinkers have pointed out that their trial-and-error activity apparently led nowhere, and that it was only after they put the problem aside that inspiration came.

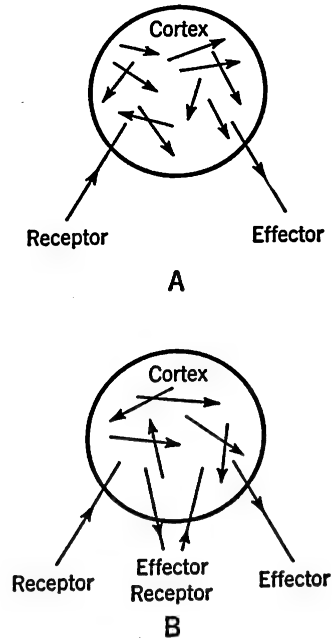
Verification or revision

Inspiration is sometimes the final stage in creative thinking. In most instances, however, it is necessary to evaluate, test out, and

perhaps revise, the idea that comes to us. Is it logical? We can at times determine whether an idea is logical by casting it into syllogistic form and testing it by the laws of formal logic. Very often, however, it is necessary to carry out controlled observations which will prove whether or not an inspiration is correct, or workable, or needs revision.

This is the method followed by scientists. Likewise, the inventor must show that his ideas work in practice as well as in his blueprints. Indeed, the scientist, inventor, and artist frequently find that their inspirations need considerable modification before their creative work is satisfactory.

The inspiration, in other words, is only a prelude to further intensive work. It is one thing for the person to get the idea for a picture, a novel, a poem, an invention, or a theory, and quite another to paint the picture, write the novel, write the poem, produce the invention, or formulate and verify the theory.



138 **The Central (A) and Central-Peripheral (B) Views of Thinking**

(Suggested by Dashiell, J. F., Fundamentals of General Psychology, *3rd Ed. Boston: Houghton Mifflin, 1949, p. 589.)*

THINKING AND THE BRAIN

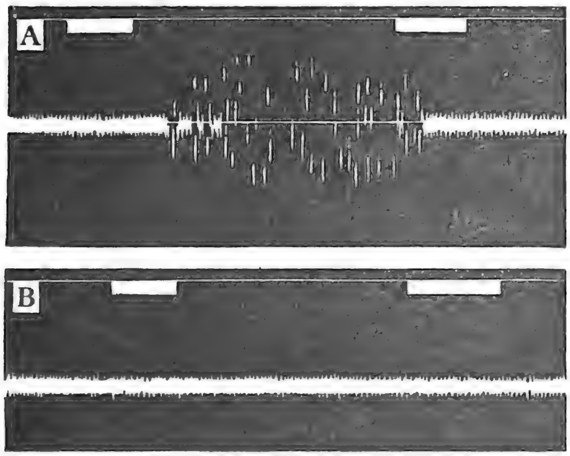
Do we think with our whole body, or can we think with our brains alone? According to one theory, we may think only with our brain. This is known as the *central* theory of thinking. It is represented graphically in Figure 138, A. Opposed to this is the so-called *peripheral* or *motor* theory, a theory which claims that we think with the whole body. This is diagrammed in Figure 138, B. It might better be called the *peripheral-central* theory, for it gives recognition to the fact that, even though we may not think with our brains alone, the brain plays a predominant role in all thinking.

This view stresses the fact that impulses aroused by stimulation go (1) to the cerebral cortex, where they initiate sensory, motor, and associated functions, and (2) to the effectors, where they initiate motor activities. Motor activities in turn arouse impulses (kinesthetic) which go (1) to the cerebral cortex and (2) to the same or other effectors. Likewise, cortical activities, through the motor pathways, also initiate activities in muscles, glands, and visceral structures. These activities cause further impulses to go (1) to the cerebral cortex, and (2) to the same or other effectors. There is thus a constant interplay of cortical and motor activities. The cortex, however, plays the dominant role because of its connector functions as well as because it contains the records of past experiences, the symbolic processes with which we think.

As already suggested, thinking is often associated with activities in the muscles of tongue and throat. In one study, electrodes were placed on the subject's tongue or underlip. These were connected with a string galvanometer. When the subject imagined counting one-two-three, the galva-

nometer needle, which had been at rest, showed three marked series of excursions, indicating that action currents were coming from the tongue or lips. Such instructions as, "imagine telling your friend the date," "recall a poem or song," "multiply certain numbers," and "think of eternity," brought action currents very similar to those involved in actually saying the words.[28]

Subjects who had been trained to relax their muscles at a signal to do so were instructed, "at the first signal, imagine lifting a ten-pound weight in the right forearm, and at the second signal, relax." A record of action potentials picked up from the subject's right biceps muscle while he was imagining this activity is shown in Figure 139, A. B is a record taken from the corresponding muscle in the left forearm when the subject imagined lifting the weight in his right hand. It is evident from this, and many comparable observations, that thinking of or imagining an activity is associated with slight contractions of relevant muscle fibers.



139 Action Currents (Electrical Potentials) Obtained from the Right Biceps (A) and Left Biceps (B), While the Subject Imagined Lifting a Weight with His Right Arm

The white marks at the top of each record indicate (left) the onset of the instruction, "imagine lifting a ten-pound weight in the right forearm," and (right) the onset of the cue for resumption of relaxation. (From Jacobson, E., "Electrophysiology of Mental Activities." American Journal of Psychology, *1932, vol. 44, facing p. 683.)*

Action currents are obtained from the hands of deaf mutes during thought.[29] Sometimes the activities of the hands are of sufficient magnitude to be detected with the naked eye. In one study, deaf mutes and normal subjects were asked to multiply mentally, divide mentally, and so on. Under these conditions, 80 per cent of the deaf mutes had action currents in the hands. Only 30 per cent of the hearing subjects showed such responses. The reason that hearing subjects exhibited electrical potentials in the hands at all may be attributed to the fact that even they often use, or have used, their hands in making calculations — with or without using a pencil or chalk. The average magnitude of the responses obtained from the hands was about four times larger for the deaf mute than for the hearing subjects.

Added to these investigations of vocal and other muscular activities are a number dealing with eye movements during the process of thinking or imagining. Eye movements during imagination of an object are often very similar to those made in original examination of it.[30] Eye movements made in recalling memorized verbal material are also often similar to those made in the original reading of the material.[31]

These facts show that we think, at least at times, with the whole body. They do not allow us to conclude that motor activities, either alone or in relation to cerebral activities, are thought. One could argue that they are caused by thought, assumed to be a central phenomenon, just as well as that they constitute thinking. The results do not, moreover, allow us to conclude that motor activities are essential to thought. It is conceivable that one could think on a purely central basis, without any action currents occurring in his tongue, eye, or other muscles. It would be impossible either to prove

or disprove this central theory, for our only evidence of the process of thinking comes from peripheral activities, verbal or otherwise.

We have already indicated (pp. 68–70) that the frontal lobes play an important role in reasoning. When these lobes are completely removed in animals below man, evidence of reasoning no longer occurs. The role of the frontal lobes in human thinking is pictured by two brain surgeons who have specialized in the cutting or removing of tissues in the frontal lobes, with a view to alleviating mental illnesses of various kinds. This is the field of *psychosurgery*. The surgeons say:

> Aside from certain small areas that mediate voluntary control over muscular movements and the regulation of visceral functions, the rest of the frontal cortex is, according to our hypothesis, concerned with the projection of the whole individual into the future. With the intact brain the individual is able to foresee, to see before, to forecast the results of certain activities that he is to initiate in the future, and he can visualize what effect these actions will have upon himself and upon his environment. Case 38 expressed this concept almost directly. When he was questioned about his activities in slapping the nurses and pulling the fixtures from the wall in the hospital, he replied, "Now that I have done it, I can see that it was not the thing to do, but beforehand I couldn't say whether or not it would be all right."
>
> The patient with normally functioning frontal lobes can presumably define the goal toward which he is working and estimate more or less the nearness to which he approaches it. By projecting himself into the future in his mind's eye, he is calling upon his cortical mechanisms to synthesize past experience as his guide and upon his emotional mechanisms for the driving force in the search for satisfaction and the avoidance of distress. Once the goal is set, he is further calling upon his cortical mechanisms to assemble the various parts of the problem and to select a proper course from among the many alternatives that present themselves to him at the completion of each separate step. The total behavior is modified in response to every change of condition. Satisfaction or dissatisfaction depends upon the recognition of the nearness that actuality approaches the ideal that he has foreseen. . . .
>
> If this hypothesis is accepted, it makes more easily understandable many of the observed facts concerning frontal lobe disease. Inertia and lack of ambition, reduction in consecutive thinking, loss of what is commonly called *self-consciousness*, indifference to the opinions of others, satisfaction with performance, even though this may be of inferior quality and quantity.[32]

SUMMARY

Thinking is manipulating the world internally, using modifications of the organism which represent the things that produced them. Modifications with this representative function are symbolic processes. Although the term *thinking* covers such activities as thinking of, or recalling, something; reverie, or free association; fantasy, or day-dreaming; and reasoning, or implicit problem solving, psychologists give their major attention to the latter process.

The existence of reasoning in animals ranging from rat to man is clearly indicated by results obtained with several learning problems. These are problems which could not conceivably be learned without the use of symbols.

One type of reasoning problem gives the subject two separate "experiences" and then confronts him with a problem he can solve immediately only by combining these experiences. Rats and children have been the only subjects used in such experiments. Rats have evidenced the ability to solve simple problems by "putting two and two together." Children have been given similar problems of greater complexity. The ability of children to solve these problems increases with

age. Solution rarely occurs before the fifth year.

Certain multiple-choice problems have been solved by a number of animals ranging from birds to man, the complexity of solved problems increasing, in general, with the nearness of the animal to the human level. The problem calls for a response to relationship, such as to the middle door or key, of a constantly varying number of doors or keys presented in varying positions.

The double-alternation problem utilizes a temporal maze or double-box situation where the subject is required to make a temporally related series of reactions, for example, a right-right-left-left sequence, without differential sensory cues to guide him. The ability to solve this problem and to extend the sequence beyond that involved in training increases as we go up the scale from rat to man. In human children, ability to solve the double-alternation problem increases with age. Children below the age of four years seldom solve it. The problem is quite readily learned by adults, who extend the series without difficulty. It is usually verbalized by children and adults, the subject saying, "right, right, left, left," as he responds.

When confronted by problems or difficulties which cannot be met in a routine manner, human beings make inferences concerning the cause of their difficulties or the solutions of their problems. This is the most important step in human reasoning. Inferences are made on the basis of past experience, and they are limited in scope and relevance by the limitations of experience. Before accepting or rejecting inferences we usually evaluate them, either by further implicit activity or by carrying out an actual check on their applicability.

Our associational processes in reasoning are directed by the nature of the problem, as we conceive it. The problem gives us a set, or determining tendency, which facilitates recall of certain items and inhibits recall of others not relevant to the situation. Sometimes, despite this general directional tendency, we are hindered by limitations which we place on our own thinking. We accept the first inference that comes to mind, perhaps, and let our thoughts go in the direction suggested. Delusions often have such a basis. Think, too, of the limitations on such reasoning in the nine-dot problem when the individual assumes that he must keep within the limits of the dots. The value of constantly changing directions, getting new inferences when one that we already have will not work, has been shown in problem-solving experiments with college students. Instructions to change direction frequently led to an increase in the number of subjects achieving solutions.

Much human thinking is doubtless subvocal talking, but imagery and possibly other processes also play an important role. Many of the terms used in thinking represent common properties of things that are diverse. These are conceptual terms, and the ideational processes which underlie them are called concepts. Getting the concept triangularity, dog, tree, or the like, requires that the individual discriminate the common properties of the different objects — that he discern similarity amid diversity. This is the process known as abstracting. In order to develop a concept, it is also necessary that the individual generalize — that he relate the similarities in such a manner as to derive a generalization like "all objects having these properties are trees."

Concepts, such as the concept of triangularity, have been developed by animals beginning with the rat. The general method followed is dissociation by varying concomitants, for the triangularity factor is embedded in varied patterns from which the subject must learn to dissociate it. Research on concept formation in adults, using Chinese characters, suggests that the most efficient method of teaching individuals to abstract and generalize is that of presenting

total situations with the common elements emphasized. The common properties of many situations which call for concept formation are by no means obvious, and the individual must "figure them out." Children also learn many of their concepts by asking questions. Children's concepts, at first very inadequate, approach those of their elders as they grow older.

Creative thinking is especially evident in the productions of such people as scientists, inventors, artists, and poets. Much trial-and-error underlies most creative work. Inspirations, insights, or illuminations are its spectacular aspects. Analysis of creative thinking by the thinkers themselves, and by others, has led to the conclusion that four stages are more or less clearly evident. These are: preparation, the gathering of relevant information and attempts to organize it; incubation, a period of relative inactivity, perhaps with recurrence of ideas about the problem, but no evident progress; inspiration, the sudden illumination, or "aha" experience; and verification or revision, the testing-out and evaluation of the idea, inference, or hypothesis, either by implicit processes or by actual experiment. The last stage is not always present, but it is required whenever anything is done about the inspiration. It is essential in scientific research and in certain inventive pursuits.

Although several studies have shown that thinking is associated with a variety of muscular activities, thus offering support for the peripheral-central or motor theory of thinking, the findings have not disproved the central theory, which claims that thinking can occur in the brain alone; that is, without motor processes being present. As we shall observe again in the discussion of attending, it is difficult, if not impossible, to get crucial evidence for or against a central theory. The reason is that our only index of what central activities are occurring must involve some sort of motor process.

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Part Five

Motivation of Behavior

The literal meaning of motivation is much broader than its psychological meaning. Literally, to motivate is to move — that is, to activate — and anything which activates is a motive. In this sense, every stimulus which arouses a response is a motive, and, since every response is preceded by internal or external stimulation of some kind, all behavior is motivated. In current psychological usage, however, the term *motivation* applies only when inner controls are involved. The term is not applied to tropistic behavior, where responses are controlled exclusively by external stimuli. We do not say that the water scorpion, which may be made to move in any desired direction merely by changing the direction of light, is motivated. Nor do we say that the reflex contraction of our pupils in response to light is motivated. So far as tropistic and reflex responses are concerned, organisms act much as puppets. They are lacking in autonomy. Their responses are governed solely by the structures with which they were endowed and by the external forces which happen to be operative at the moment of response.

As we ascend the scale from lower to higher organisms, puppet-like behavior becomes less evident. Rather than being ruled exclusively, or even predominantly, by the external stimuli present at any moment, the higher organisms are governed by changing physiological states, such as underlie hunger and thirst; and by the neural records produced by previous experience. Thus, one cannot predict that an animal will drink water placed before it unless one knows that the animal is thirsty. One cannot predict whether a child will approach or shrink from fire unless one knows what its previous experience with fire has been. The psychology of motivation is a study of the inner controls which have their roots in changing physiological conditions and in previous experience. It may be said to deal with the inner springs of conduct or with the mainsprings of behavior. Looked at from another angle, the psychology of human motivation aims to discover *why* we behave like human beings.

As one may have gathered from the foregoing, motives are inferred or deduced

from observable behavior. We do not observe them directly any more than the physicist observes the force of gravity directly. The physicist observes many different phenomena which involve a common principle — a tendency to move toward the center of the earth. He calls this tendency *gravity*.

Similarly, we observe many different kinds of behavior, all of which have in common the fact that they are controlled from within the organism primarily, and by external stimuli only secondarily. We use the term *motivation* to represent this inner control. Moreover, we name the various motives in terms of behavioral variations. If the organism's activity is directed toward food, we infer the motive of hunger; if it is directed toward water, we infer the motive of thirst.

It often happens that many different behavior patterns are similarly motivated. Thus, an individual motivated by a desire for recognition may express that desire by engaging in athletics, accumulating wealth, writing books, or doing any of a number of things. In such instances the motive is inferred from behavior. It may be named by the individual himself. He may say, "All of my activities are motivated by desire to receive recognition from my fellow men." He may, of course, not know his true motives (as we shall observe in a discussion of unconscious motivation), and he may not be telling us the truth. However, an excursion into his life history often indicates the accuracy of his and our own judgment.

It often happens, too, that different motives produce the same type of reaction. For instance, murder may be the outcome of anger, fear, greed, lust, or any of several other motives. Discovery of the real motive, or motives, comes from a study of other behavior preceding or following the crime, the individual's own statements, and his life history.

We are all acquainted with many motivational terms, such as *aim, drive, wish, purpose, desire, craving, goal, incentive, attitude, interest, choice, preference,* and *will.* Each of these terms suggests regulation of his own behavior by the individual. Several everyday motivational terms, as *desire* and *wish,* are practically synonyms. Others, as *drive* and *will,* have opposite meanings. Thus, we say that an individual is driven to an act or, on the contrary, that he acts of his own free will.

These everyday motivational terms are, at times, used as though they explained why an individual does what he does. We say that he does such and such because he *chooses* to do it, because it suits his *purposes,* or because he is *driven by desire.* Of course, these are explanations only in the most superficial sense, as is the statement that we sleep because we are sleepy. Strictly speaking, the terms are merely labels. The crucial problem is that of discovering why the individual chooses as he does, why it suits his purposes to do this rather than that, or why he has the desire to act in a certain way. Psychology seeks explanation at this more basic level. It seeks, as far as possible, to get below the surface — to discover underlying causes.

Some motives, of which hunger and thirst are good examples, have a purely physiological explanation. They are inborn, universal, and ineradicable. Life itself depends upon their satisfaction. In the following chapter we consider some of these basic motives and the physiological conditions which underlie them.

11 PHYSIOLOGICAL DRIVES

Homeostasis • Drives: Physiological drives; incentives and motives • Hunger: Hunger and blood chemistry; hunger drives; cafeteria feeding; food preferences; hunger in everyday life • Sex: The human sex drive • Thirst • Other Physiological Drives • The Relative Strength of Physiological Drives: Pitting one drive against another; the obstruction method • Physiological Drives, Reflexes, and Instincts: The relation between drives, reflexes, and instincts • The Sex Drive and Mating • Maternal Behavior • Man Is Primarily a Creature of Habit • Summary

THE STUFF OUT OF WHICH WE ARE MADE is dissipated and needs replenishment from time to time. Therefore, we must eat and drink. Waste products accumulate and must be eliminated. Because of this, we have excretory needs. In order to survive as intact organisms, we must withdraw from anything which seriously injures our tissues. Perpetuation of our kind — and perhaps optimal enjoyment of human adult life — depends upon sexual activity. Conditions of fatigue demand that we rest from time to time. Thus, we have a number of needs whose basis is purely physiological. Some of these arouse positive reactions, such as appetite and exploration, while others arouse negative reactions, such as aversion for and withdrawal from injurious or potentially injurious situations.

When physiological needs are not immediately satisfied, the physiological balance of the organism is disturbed. Activities are then aroused which continue until either the need is satisfied or the organism has become exhausted. When we say that certain substances, such as food or water, satisfy the need, we are saying that they restore the physiological balance which a condition of want or deprivation has disturbed.

HOMEOSTASIS

One very interesting interpretation of this restoration of physiological balance is involved in the concept of *homeostasis*, which carries the implication that organisms, by their own activity, tend to maintain a constant state. As one physiologist so aptly put it, "The living being is an agency of such sort that each disturbing influence induces by itself the calling forth of compensatory activity to neutralize or repair the disturbance." [1] He had in mind such compensatory activities as the restoration of injured tissues by white blood cells and the maintenance of a constant body temperature through sweating.

Activities associated with several of our physiological needs, although not so automatic as the processes mentioned, are certainly compensatory in nature. The activity aroused by an unsatisfied need for food serves to bring food, which removes the hunger. The pressure of waste products arouses activities which eliminate the pressure. Accumulation of fatigue products leads to reduced activity and dissipation of the fatigued state. A similar interpretation may

be placed on activities associated with many physiological needs.

It should not be assumed that all activities elicited when a need first arises are those activities, and only those, required in satisfying the need. In some instances — and the excretory needs provide a good example — it is true that the need automatically sets in motion those acts which satisfy or relieve it. In cases like hunger, on the other hand, the direction in which the need is to be satisfied must be learned. Thus, the animal motivated for the first time by a need for food does not know that food will restore the physiological balance. The animal sucks — which is itself an appropriate response — but it sucks anything which comes to its mouth whether this be hair, skin, straw, cloth, or nipple. However, it is only when the nipple is sucked that hunger is alleviated. Eventually the animal comes to suck this alone.

DRIVES

Conditions associated with deprivation of needed substances (like food) or needed activities (like excretion) seem to drive the organism to activity. For this reason, the term *drive* is widely used in discussions of animal motivation. The inborn drives which stem from basic physiological needs are frequently distinguished from less fundamental drives — that is, those acquired during the individual's lifetime — by calling them *physiological* or *animal* drives.

Physiological drives

The term *physiological drive* customarily refers to the physiological condition which drives the animal to activity. This condition is a consequence of unsatisfied need, but some writers fail to distinguish between physiological drive and need.

Physiological drives have been given specific names in terms of (1) the kind of act in which general activity ends, (2) the sort of deprivation which produces the activity in question, and (3) the physiological conditions which are known to underlie activity. In some instances, we know nothing of the sort of deprivation which arouses a particular form of activity nor of the physiological basis. Thus, we speak of an "exploratory drive," solely on the basis that an animal from time to time engages in vigorous activity which appears to be exploratory. Some inner condition which drives the animal to explore is in this case inferred purely from behavior. The hunger drive, on the other hand, may be so designated in terms of the fact that the activity in question (1) culminates with eating, (2) is aroused by deprivation of food, and (3) is associated with physiological conditions, such as stomach contractions and lowered blood sugar, which, in human beings, are related to the experience of hunger.

Incentives and motives

Objects (like food), situations (like changed temperature conditions), or activities (like excretion) which provide a means of culminating motivated activities are referred to as *incentives* or *goal objects.* Moreover, when incentive-directed behavior is involved, the term *motive* is often used in preference to *drive.* An animal activated by hunger eventually acquires a food-seeking motive. Activity aroused by drives, as such, may be blind, whereas activity aroused by motives has direction. In other words, drives provide only a "push from within," whereas motives involve a "push in some relevant direction."

It may be pointed out also that incentives appear to attract or "pull" the organism in certain directions. In the case of aversions, like the aversion for painful stimulation, which repels rather than attracts, we refer to the repelling object or situation as a *deterrent.*

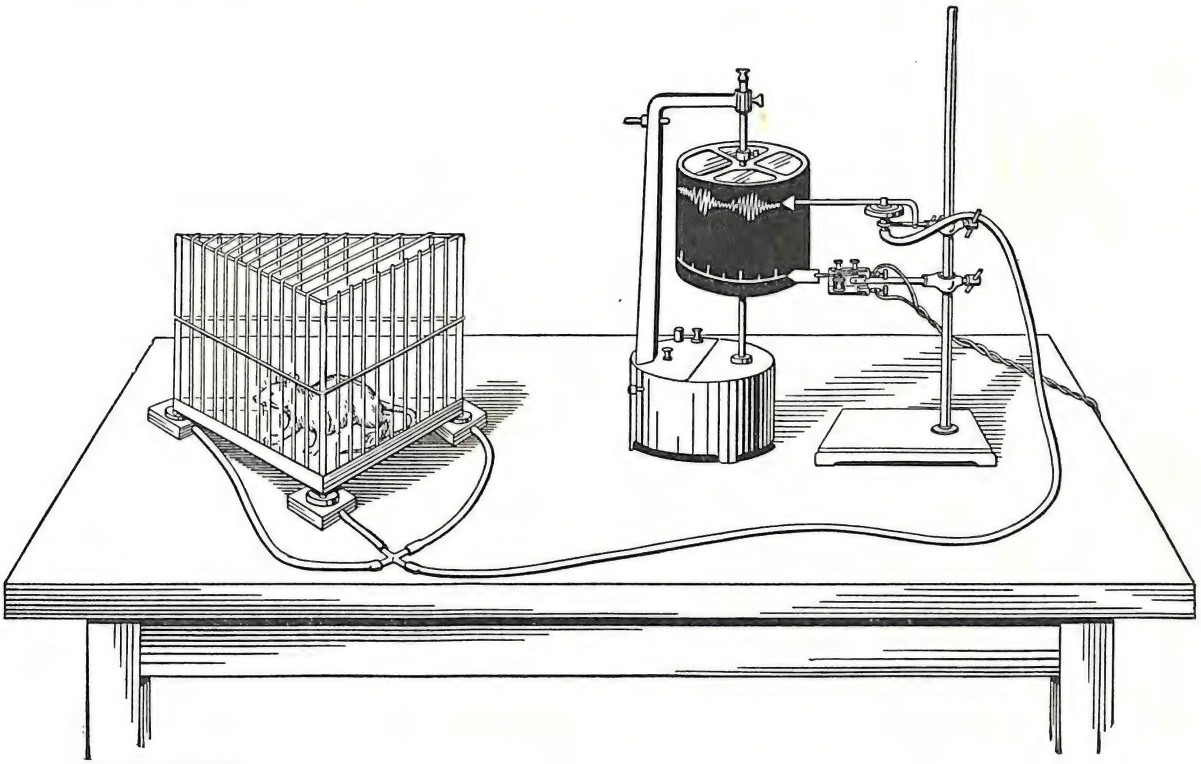
HUNGER

In research on physiological drives, the usual procedure has been to record general activity and then, by operative or other means, to investigate the underlying physiological conditions.

When rats are deprived of food and placed in tambour-mounted cages, like that illustrated in Figure 140, they show periodic spurts of activity. Each spurt occurs after an interval averaging about two hours.

If two cages are placed side by side with a passageway going from one to the other, and one of these cages contains food, the rat enters the food cage at about the middle of each activity period. It rarely enters the food cage except at this time. This suggests that the periodic spurt of activity is motivated by hunger. After the animal has eaten and returned to the home cage, activity continues for a short period.[2]

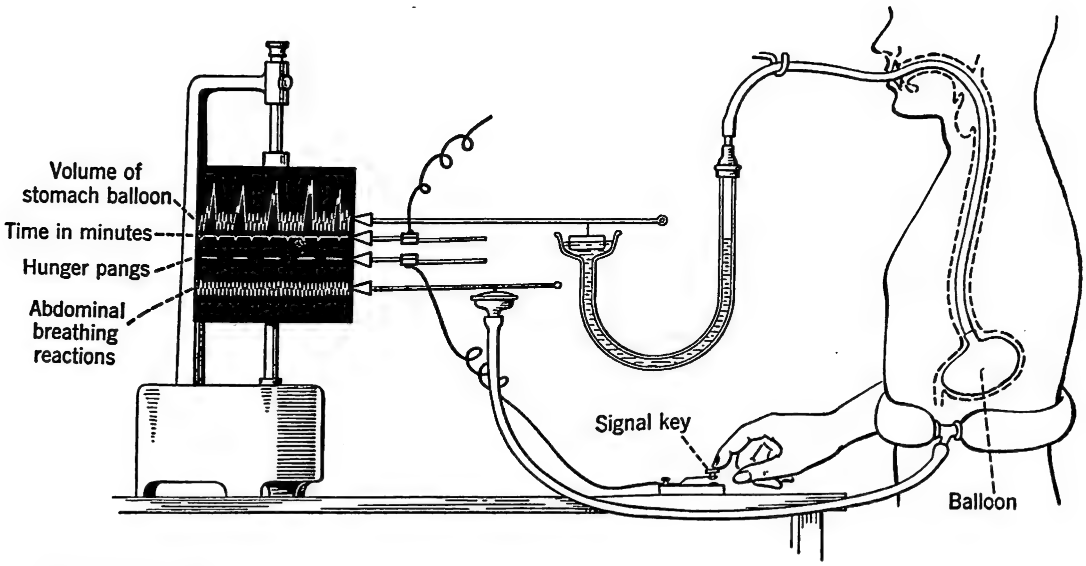
Nothing at all is known about a rat's experiences; hence, we use the term *hunger* in a purely physiological sense. Early research with human beings, however, showed that the aching or gnawing experiences known as *hunger pangs* are associated



140

Tambour-Mounted Cage Used to Study the Hunger Rhythm in Rats

The triangular cage rests on three tambours, one under each corner. Each of these tambours (small cups topped with a sheet of rubber) is connected by rubber tubes to a recording tambour. Movements of the rat cause changes in air pressure within the recording system, and a writing lever moves up and down on a specially prepared smoked paper rotating on a kymograph drum at a constant speed. Thus the rat's movements produce scratches on the smoked paper. The record shown here is a reproduction of one obtained in this way. It shows two activity periods separated by an interval of approximately two hours. (After Richter.)



141

The Relation Between Hunger Pangs and Stomach Contractions

Observe that the peaks in the upper record are quite independent of abdominal breathing. They are produced by spasms of the stomach itself, and are correlated with signals given by the subject when he experiences hunger pangs. (After Cannon in The Handbook of General Experimental Psychology. *Worcester: Clark University Press, 1934, p. 250.)*

with muscular spasms of the stomach.[3] Subjects were trained to swallow a small rubber balloon with rubber tube attached. The balloon was inflated in the stomach and the rubber tube was then attached to a kymograph recording mechanism, so that each spasm of the stomach muscles would cause a mark to be made on the smoked drum. In addition, each subject was told to press on a key whenever he felt a hunger pang. A mark was thereby made on the drum just below the record of stomach activity. The subject's abdominal breathing was also recorded, so that the investigator could determine whether the spasms represented in the record were due to stomach or to abdominal movements. The record shown in Figure 141 is typical of those obtained under these conditions. It shows that hunger pangs coincide with stomach contractions, but are unrelated to movements of the abdominal muscles.

Hunger and blood chemistry

Various lines of evidence suggest that hunger pangs, stomach contractions, and related body activity in general, depend upon blood chemistry. In the first place, the stomach may be removed, or nerves between it and the brain severed, without destroying the hunger drive.[4] In the second place, if the blood sugar level is lowered by injections of insulin (the hormone given diabetics to control carbohydrate metabolism), stomach contractions and hunger pangs are induced. When glucose, which raises the blood sugar level, is given, these contractions and hunger pangs cease.[5] In the third place, if blood from a starved dog is injected into a normal dog, the stomach of the injected animal shows the kind of contractions found in hunger. Injection of blood from a well-fed animal, on the other hand, stops the stomach contractions.[6]

Although some aspect of blood chemistry doubtless underlies the more obvious phenomena associated with hunger, its nature is at present unknown. Studies with insulin and glucose injections support the view that blood sugar level is the basic factor. On the other hand, there is apparently no relation, under normal conditions, between the human blood sugar level and hunger. One study showed that the blood sugar level is normally about the same before, during, and after eating.[7]

The fact that injection of blood from a starving dog into a normal one elicits stomach contractions, even though the blood sugar level is not lowered by the injection, suggests that lowering of nutrient reserves releases specific chemical activators (hormones) into the blood stream and that these are responsible for stomach contractions, the experience of hunger, and general bodily activity associated with food deprivation.[8]

The view that something more subtle than stomach contractions underlies hunger is also favored by recent experiments showing that, instead of craving food as such, animals and men have a large number of specific hunger drives and associated appetites.

Hunger drives

Organisms need proteins, fats, and carbohydrates. They also need various minerals and vitamins. Lack of one of these substances often creates an appetite for it.

Cravings for special foods are well known under conditions of everyday life. Children whose diet is inadequate often develop a craving for salt, chalk, and other substances. The craving of the African pygmy for salt is well known. Certain Australian aboriginals whose diet of worms, frogs, and other small animals is lacking in normal amounts of fat develop an intense craving for fat which sometimes drives them to cannibalism.[9] Diabetics, in whom carbohydrates are not properly utilized, often develop a craving for sweets. Pregnant rats, given a free selection of food, eat about three times the usual amount of salt.[10] Certain glandular disturbances produce intense appetite for such substances as calcium and salt.[11]

When appetites for particular foodstuffs occur in animals, they have a purely physiological basis. As is well known, however, human appetites are influenced by many factors other than, or in addition to, physiological needs.

Cafeteria feeding

Animals living in a state of nature select food in accordance with bodily needs. This has suggested that the organism does not need scientists to tell it what to eat. Several laboratory experiments with pigs, cows, rats, chickens, and human infants have supported this suggestion. Such experiments are often referred to as *cafeteria-feeding* experiments because, as in a cafeteria, the organism is confronted with a wide variety of foods from which it may select freely. In one such experiment with white rats, each animal's cage contained three food trays for solid substances and a battery of glass tubes for aqueous solutions of various minerals and vitamins. Twice daily, each container was emptied and the amount taken from it was carefully determined. Eight rats were studied under such conditions for a period of several months. All of them grew normally, reproduced normally, and were normally active.[12]

A somewhat comparable cafeteria experiment with fifteen human infants, who selected their own food over periods ranging from six months to four and a half years, yielded similar results.[13]

Each child was fed by the cafeteria method from the time of weaning, which varied between six and eleven months. The general procedure was to place a number of small dishes and glasses of food before the child and to make no comments concerning

the food eaten or the manner of eating it. As soon as the child reached for a dish, a spoonful of the foodstuff was picked up. If he failed to open his mouth voluntarily, the food was replaced. He was allowed to eat with fingers or, at a later age, with implements. The important point is that he was given no suggestions of any kind concerning what to eat, when to eat, or how to eat. No comments were made concerning what he actually ate.

Some twelve to twenty foods were presented at each meal, three times daily at first and then four times daily. Selections were from a total of thirty-four different foods. Most of these were simple foods, not mixtures; some were raw and others cooked. At first, the children sometimes spat out food after it was in the mouth, but they soon learned to make their selections without tasting the food. In other words, their immediate selections were eventually based on vision or smell. After a child had definitely finished eating (from twenty to thirty minutes), the food tray was removed, and the portions still remaining were weighed. Note was also taken of food spilled.

The results were quite conclusive. All children thrived on a diet of their own choosing. Their growth was in advance of standard growth curves. No bad effects of any kind were noted. The diet chosen was not widely different from that recommended by nutrition experts. As might be expected, preferences for particular foods varied from one child to another and in the same child from time to time.

Food preferences

Rats and other animals have definite food preferences. This is shown by their selection of certain foodstuffs much more often than others which are equally accessible. Several experiments have shown, moreover, that these preferences change with bodily need. Thus, rats which ordinarily prefer sugar to fat will select fat rather than sugar if they have been fat-starved. Likewise, rats deprived of vitamin B_1 soon exhibit a marked preference for foods rich in vitamin B_1.[14]

How do organisms come to select the proper diet? One possible basis of selection is trial and error. That is to say, the organism selects at random to begin with, but learns that certain substances (recognized by visual appearance, feel, taste, or smell) relieve tensions, or restore physiological balances, while others do not. It then "seeks" these substances when such tensions arise. Another possible basis is that a physiological need affects directly the senses of taste, and smell, or both, so that the organism is attracted to certain substances and repelled by others. According to this view, the need for protein would make meat smell or taste "good" and thus attract the organism.

Both of these views are perhaps partially correct, but neither is adequate, by itself, to account for the satisfaction of all hungers. The chief difficulty with the trial-and-error view, when it is considered alone, is that the effects which follow eating are sometimes long delayed. To an animal deprived of carbohydrate, say, invert sugar would have an almost immediate effect and it is easy to see how sugar would eventually be sought out. In the case of many other substances, however, it may be an hour or so before eating restores the physiological balance. Here it is difficult to see how the association of a particular food with satisfaction of a particular hunger would occur. The chief difficulty with the second view, when considered in isolation, is that the initial selection in cafeteria situations is indiscriminate. If taste were in itself an adequate guide, selection should be perfect, or nearly so, from the beginning. Possibly changes in taste sensitivity aroused by a condition of need aid the trial-and-error learning which eventually guides the organism to the needed foodstuffs.

Hunger in everyday life

In human beings especially, appetite may be stimulated by the sight, odor, and taste of food, even though physiological hunger is absent. It is stimulated by "appetizers" of various kinds. Seeing others eat also stimulates eating. This influences not only the time at which we eat, but also the amount and kind of food eaten.

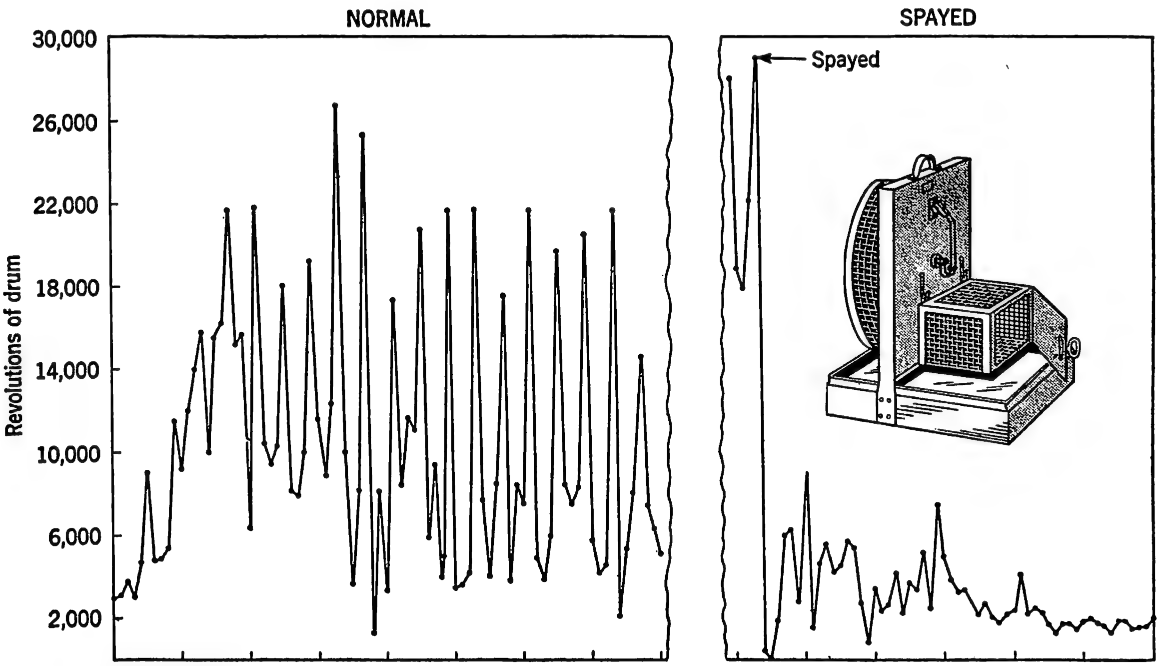
The influence of social eating upon the amount eaten is observed even in animals. If a record is kept of the amount eaten when the animal is in isolation and when it is in the presence of other eaters, we find that more food is eaten in the social situation.[15]

Rhythms of eating are also present, irrespective of physiological rhythms. We eat two or three times a day, or as many times as is customary, whether we are hungry or not. Habit obviously plays a big part in all such variations in the occasions for eating. Habit and social customs account, too, for most of our aversions for certain foods, such as horse meat.

But even the aversion to eating human flesh is sometimes overcome. Members of the George Donner expedition resorted to cannibalism when trapped in what is now known as the Donner Pass, while headed for the California gold fields.[16]

SEX

When rats live in cages like the one illustrated in Figure 142, they spend part of their



142

Activity Level as Measured with a Revolving Drum

Each succeeding dot in the curve represents a day. Observe that the normal rat has a peak level of activity every fourth day. The age range is from 59 to 129 days. At the right, drawn to the same scale, is shown the drop in activity level when a normal rat was spayed. The record began at 117 days and ended at 177 days. A revolving drum is shown in the insert. (Arranged from Richter and others.)

time running in the attached rotating drum. The drum contains a counter which records revolutions in either direction. From the number of revolutions one may calculate the distance run. Thus, it is calculated that female rats run from one to many miles per day. Male rats show much less activity than females. Moreover, their level of activity fluctuates in no regular manner from day to day. The female rat, on the other hand, usually runs a mile or so a day for from three to four days and then shows a marked spurt on the fourth or fifth day. At the peak of the cycle, a female often runs as far as fifteen miles in a day.

The observation that male rats living in cages like the one illustrated are much less active than females and that they show no cycle such as that observed in females suggests, of course, that the high activity level and the cyclical variation in female rats are due to some motivating factor peculiar to females. Thus, a sexual basis appears probable.

During the period of heightened activity, when the female rat undergoes certain tissue changes in the sex organs and ovaries, it engages in and actively solicits mating. On the days of low activity, the animal refuses to mate. These facts suggest that the spurt in activity on the fourth or fifth day is motivated either by tissue changes in the sex organs, by secretions from the ovaries, or both. Removal of the sex organs does not affect the cycle; hence, it remains to determine what influence is exerted by the ovaries.

Evidence that the motivating factor is a secretion from the ovaries comes from various sources. In the first place, the activity cycle makes its appearance at the time of puberty and ceases when the menopause is reached. In the second place, as illustrated in Figure 142, removing the ovaries reduces activity and abolishes the cycle. Replacement of ovaries by grafting restores the activity level and the cycle. In the third place, the cyclical behavior is restored by periodic injections of a secretion from the ovaries. The hormone especially involved is an estrogen known as *estrin.* Finally, male rats manifest a typical female activity level and cycle when their testes are removed and ovaries substituted.[17]

Experiments on male rats, guinea pigs, and other mammals castrated prior to puberty show that secretions from the testes are necessary for sexual behavior and also for maintenance of a normal activity level. Castration after puberty has been attained also reduces the activity level, but it does not always eliminate sexual behavior. Injection of *testosterone,* an androgenic hormone, increases the general activity level and at the same time revives the specific sexual reactions of castrated rats. This hormone thus appears to play a key role in the sexual life of male animals.[18]

Recent research has shown that the neuromuscular mechanisms involved in sexual behavior develop in the absence of the estrogenic and androgenic hormones, but that these hormones are necessary to arouse sexual excitability and to activate sexual mechanisms.[19]

Although the general activity level of rats is greatly influenced by secretions from the gonads, it is also influenced by secretions from other glands. A secretion from the anterior lobe of the pituitary gland (at the base of the brain) and another from the cortex of the adrenal glands (above each kidney) are especially involved.

The glandular system is an interlocking one, with the pituitary gland playing a major role. Inadequate pituitary function disturbs the functioning of the gonads and other glands. We do not know the precise role played by each of the glands, either in motivating general activity or specific sex behavior. It has been clearly established, however, that removal of the gonads, the anterior pituitary, or the cortex of each adrenal gland reduces both general activity and

sexual behavior to a low level. Removal of the thyroid gland also decreases activity, but not so much as removal of the other glands.[20]

The human sex drive

Although the human sex drive shows no periodicity as clear-cut as that found in female rats, it does have a comparable glandular origin. Removal of ovaries prior to puberty leads to absence of adult female characteristics, and produces what appears to be an individual of neutral sex. There is also complete absence of a sex drive. Human males are similarly affected by early castration. When removal of either male or female gonads occurs in mature individuals, there may be little influence upon sexual activity. Continuance of sexual motivation under these conditions probably results from retention of interests and habits which, while they originally developed under the influence of the gonads, are no longer dependent upon secretions from these glands. It is interesting to observe, in this connection, that men and women whose gonads have degenerated during middle or late life (the menopause in women) usually continue to participate in sexual activities. In those cases where a decline in sexual vigor does occur, it can now be revived through injection of hormones, estrin for women, and testosterone for men.[21]

The human sex drive varies considerably both in its intensity from one individual to another and in the directions in which satisfaction may occur. Repressive influences (such as ideas that sex is evil, or dirty) sometimes lead to absence of sex interests and inability to engage in sexual activity, despite the fact that the individual is structurally normal. Frigidity (in women) and impotence (in men) represent this low tide in sexual drive. At the other extremes are nymphomania (in women) and satyriasis (in men). Individuals thus affected, because of excessive glandular secretions or excessive social stimulation involving sex, have an unusually strong sex drive.[22] Kinsey's study, based upon questionnaire data, suggests that there is a very large variation in frequency of male sexual outlet. His tables indicate a variation of from 0 to over 29 outlets per week.[23]

Variations in the direction of the sex drive often begin to develop in childhood. Just as organisms driven by hunger continue to seek out that which satisfies their hunger, so do they seek a repetition of those acts which have in the past released their sexual tensions. It often happens that a child whose sex urge has already made its appearance stimulates itself sexually, is stimulated sexually by another member of the same sex, or receives sexual stimulation from some object or situation. The satisfaction obtained from such stimulation may lead the individual to seek a repetition of the stimulation. Continued into adulthood, unusual directions of sexual satisfaction may prevent the kinds of sexual release sanctioned by society. The individual is then regarded by the group (and often by himself) as abnormal or perverted. Similar "perversions" often occur in animals (and especially in the higher ones), but they are more frequent and more varied in man.[24]

THIRST

Drinking, like eating, tends to be periodic. The daily water intake of white rats is related to the area of their body surface.[25] When the animal is deprived of water over a period of hours, it becomes excessively active even though all other needs are satisfied. It is apparent, therefore, that something within the organism, present in times of water deficit, drives the animal to activity.[26]

What provides the drive behind water consumption? According to a well-known theory, the drive comes from dryness of the mucous lining of the mouth and throat.[27] When the organism is deprived of water over a period of several hours, the mouth

and throat become dry. This dryness, reflecting dehydration of body tissues in general, is assumed to underlie thirst experience, general activity associated with water deprivation, seeking of water once the organism has learned that this will alleviate its need, and drinking of an amount sufficient to satisfy bodily need.

When water is placed in the stomach directly, as in tube feeding, a period of several minutes must elapse before the thirst experience ceases. This suggests that the water must get into the tissues sufficiently to remove the dryness of mouth and throat. On the other hand, merely wetting the mouth temporarily removes the thirst experience.

Dogs subjected to different degrees of water deficit drink an amount of water directly proportional to the known deficit.[28] Such an accurate "estimation" by the dog of its need for water is hard to explain in terms of dryness of the mouth and throat. The first mouthful would wet the mouth and throat, removing the condition which might otherwise provide the dog with a guide to the amount needed. As in the case of hunger, some unknown condition or conditions, aroused by a state of deficit must regulate both thirst and water consumption. The most important single condition appears to be cellular dehydration. This stimulates secretion of a pituitary hormone, which may have some regulatory function in relation to water consumption.[29]

OTHER PHYSIOLOGICAL DRIVES

No useful purpose would be served by an attempt to list all of the physiological needs and their associated drives and motives. As a matter of fact, there are perhaps many needs of which we are unaware, because they are so thoroughly and automatically satisfied. Under ordinary circumstances, such needs would not motivate behavior.

The way in which we are supplied with oxygen makes an interesting example. We live in an ocean of air which is one-fifth oxygen. If deprived of it for even a few minutes one dies. Here certainly is evidence of physiological *need,* yet, curiously enough, the need is not the basis of any strong physiological drive. The reason that man can continue to exist without such a drive is that under normal circumstances the need for oxygen is completely satisfied as a consequence of the satisfaction of a different need — the need to eliminate carbon dioxide. This function, with which a very strong drive is associated, is carried on by the lungs simultaneously with oxygenation of the blood. If a man is prevented from breathing, he soon gasps and struggles. He "wants air" — but he "wants" it only to flush out the accumulating carbon dioxide. Deoxygenated air, or pure nitrogen, relieves him as adequately as normal air would; and when the carbon dioxide concentration is normal he will relax contentedly in a deoxygenated atmosphere, there to succumb to asphyxiation while feeling neither want nor discomfort.[30] Men who ascend to great heights in balloons or airplanes reach, at ten to twenty thousand feet, a region where, because of the thinness of the air, the amount of breathing which is adequate to eliminate wastes from the lungs does not supply sufficient oxygen. Here the airman takes additional oxygen, not because of any felt need for it but because he has been convinced by persuasion that it is necessary — much as he has been convinced of the value of vaccination against smallpox.

Some needs, like the need for food, the need for water, the need for sexual activity, the need to excrete waste products, and the need to avoid tissue injury, are known to have a physiological basis. Others, like the need for rest and the need for activity, have no clearly discernible physiological origin.

Some needs are satisfied on a purely automatic basis, as is the need for oxygen, while others, like hunger, are satisfied only as a result of the individual's efforts to adjust himself to his environment. Sometimes, as in

the case of our need to maintain a constant body temperature, a need is satisfied to some extent automatically and to some extent by individual effort. For instance, when the external temperature is higher than the normal body temperature — that is, 98.6° F. in man — sweating occurs; it becomes more profuse the higher the external temperature, although it is also affected by humidity. This process is carried out automatically by a thermostatic regulating device in the hypothalamus. We aid the process, however, by reducing the strenuousness of our activity, by drinking cold liquids, by seeking out a cooler spot, or even by the use of air-conditioning equipment. When the temperature of the body threatens to go below normal, on the other hand, we put on warmer clothing, light fires, and sometimes huddle together.

Before leaving the topic of needs and their associated drives, it should be pointed out that the life of all societies is organized around the problem of satisfying needs. All of our agricultural activities are in one way or another linked with the hunger drive. Many of the most rigid social customs in all societies have to do with regulation of sexual activity. There are definite customs for the control of excretory activities. Various measures to protect the individual from tissue injuries are instituted. Recreational activities center around the need for activity. The general tempo of life is related to temperature needs, and it has been claimed that the general drive or initiative of different races and cultural groups is largely determined by climatic conditions. In other words, it is claimed that individuals living in the tropics must slow down so much in order to maintain a normal temperature that they show little inclination for productive work. One must not, however, overlook the fact that there is usually an abundance of food in warm climates, so that the hunger drive is satisfied without arousing highly motivated activity. This, as well as temperature requirements, may underlie the lethargy which characterizes people who live in the tropics.

THE RELATIVE STRENGTH OF PHYSIOLOGICAL DRIVES

Which is the most potent of the drives common to men and animals? This question has been approached from various angles. Some have appealed to history, which shows that most of the great human struggles have been motivated directly or indirectly by hunger.[31] Others, basing their conclusion on the fact that most people with psychological disturbances who go to psychiatrists are found to be maladjusted sexually, have stressed the potency of the sex drive.

If we wish to determine the relative strength of physiological drives as such, our best approach is through experiments with animals. The chief advantages gained from using animals are: (1) no cultural influences are interwoven with the physiological as they are in man; (2) we can control the life history of animals as we cannot control the life history of man; (3) we can subject the animals to experimental controls not possible with man; and (4) we can subject to controlled conditions as many animals as are required for reliable comparisons of the different drives.

Pitting one drive against another

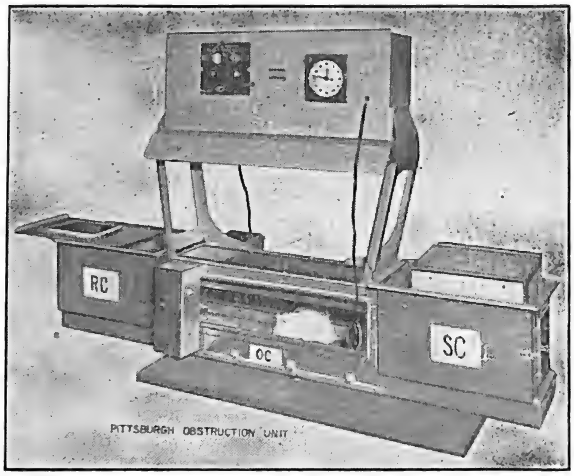
We may study the relative strength of drives by pitting one against the other and observing which one dominates. This has been done with hunger and sex. Male rats were deprived of food and sexual activity for twenty-four hours and then offered a choice between food and a female in heat. Seventy-seven per cent of the responses were to food.[32] One difficulty with such an experiment is that hunger reduces the sex drive.[33] Thus, by starving the animals for twenty-four hours, the experimenter was, as it were,

stacking the cards in favor of food selection. However, the fact that hunger reduces the sex drive suggests that hunger may be the stronger drive.

The obstruction method

The most satisfactory method yet devised to measure the relative strength of drives in animals is the *obstruction method.* This method is based on the principle that the more persistent a form of response in the presence of obstruction, the stronger its motivation. The obstruction is usually an electric grill to be crossed in approaching the incentive. Thus, as illustrated in Figure 143, the hungry rat is required to cross a charged grill to reach food at the other end of the apparatus. Since all factors other than the particular drive being investigated are held constant, it is possible to compare the relative strength of drives in terms of the average number of times the rats cross the grill in order to reach certain incentives appropriate to these. The drives investigated have been hunger, thirst, sex, maternal, and exploratory.

In the Columbia University experiments on the relative strength of these drives, comparison was in terms of the number of crossings of the grill.[34] The following aspects of the experiments were carefully controlled: (1) All rats were of the same age. (2) All animals were derived from the same genetic stock. (3) There were enough animals tested under each condition (at least twenty) so that reliable averages upon which to make the comparisons could be obtained. (4) A special shocking apparatus was devised which, in spite of differences in the susceptibility of rats to electric shock, gave each rat a shock of approximately the same strength whenever he made appropriate contact with the grill. (5) Each rat was tested for a particular motivating condition and then discarded; thus, there was no possibility that being tested for the strength of the hunger drive, say, would influence the tests for other drives. (6) Each animal, regardless of the drive being tested, was given exactly the same preliminary training. The rat was placed in the apparatus and allowed to cross the uncharged grill three times. Each time it touched the incentive (food, water, animal of the opposite sex, member



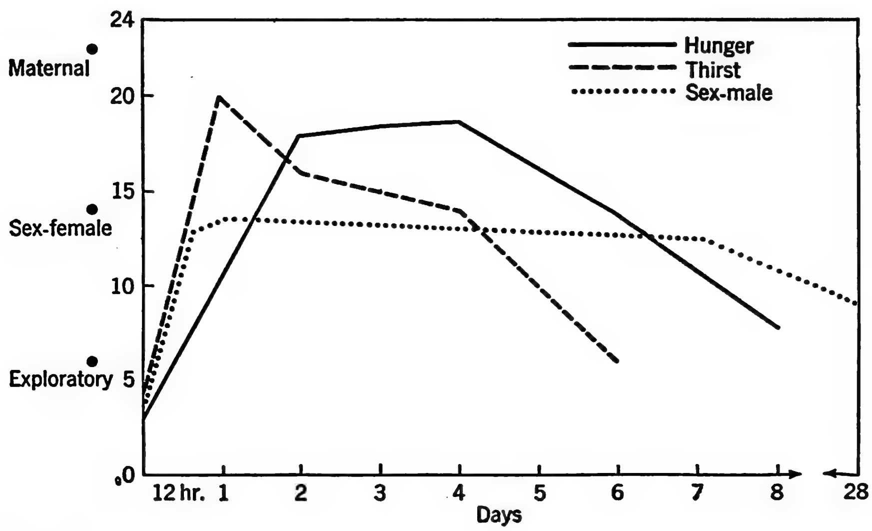
143

An Obstruction Apparatus

This is an improved apparatus based on the design of the Columbia Obstruction device. In addition to measuring the strength of physiological drives (see text), it is also used to test the ability of rats to penetrate various packaging materials. When used for this purpose, the incentive or reward end (RC) *of the obstruction compartment* (OC) *is walled off with the wrapping material to be tested. The rat-resisting qualities of the material are tested in terms of the time and effort expended in penetrating it. At the top right is a chronoscope for recording time; at the top left is an electric-shocking apparatus. This may be used as described in the text, but is disconnected when the apparatus is used to test packaging materials. When the rat enters* OC *a light beam is broken, starting the chronoscope. Another light beam is broken, stopping the chronoscope, when* RC *is entered. (From Stolurow, L. M., "Rodent Behavior in the Presence of Barriers."* J. Comp. and Physiol. Psychol., *1948, 41, p. 221.)*

of the litter, or exploration box) the rat was returned to the front of the apparatus ready for the next run. After the three preliminary runs designed to acquaint it with the fact that an incentive was available, the animal was given another run with the electric grill charged. This was to make known the presence of shock. (7) After an animal had received this preliminary training, it was allowed to remain in the apparatus for a period of twenty minutes, during which time the number of contacts and withdrawals and the number of crossings were counted. (8) In all important respects, the apparatus and general conditions under which each rat was tested remained constant.

Before a rat was tested in the above way, it was given an abundance of food, water, sex activity, and so on, so that it might become satiated. Then it was deprived of water if the thirst drive was to be studied, or of food if the hunger drive was to be investigated, but allowed full satisfaction of other needs. Thus, one group of rats was deprived of water for zero hours and tested; another for twelve hours and then tested; another for twenty-four hours; and so on up to six days. The test at zero hours was for control purposes; to see, for example, how many times an animal would cross when



144

Graph Summarizing the Results of the Columbia Obstruction Studies

The base line represents the period of deprivation, the vertical line the average number of crossings of the grill, in the standard period of twenty minutes. The dots at the side of the vertical line represent the drives for which variations in the period of deprivation were not used. Thus, the maternal drive was tested immediately after the litter had been removed to the incentive part of the obstruction apparatus. Likewise, the exploratory drive was tested without a period of delay between removal from the exploration box and the test itself. Only males were thus tested. The female sex drive is represented at the side of the graph because it was practically nonexistent, except at or near the peak day of the four-five-day cycle. Males and females did not differ in the strength of their hunger and thirst drives; hence results could be grouped. These motives, and the male sex motive, varied in strength with the length of the period of deprivation. The graph shows this variation. (After Warden.)

not thirsty. Controls were also carried out when the animal was thirsty and no water was present. Under such conditions, crossing was infrequent.

The results of these obstruction studies are summarized in Figure 144. Only crossings are shown. When no drive or a drive with no incentive was present, the average number of crossings was around three. The maternal drive produced the greatest average number of crossings (22.4), and is thus the strongest of those tested. Weakest of the drives involved in this research was the exploratory, with an average of only 6.0 crossings. The strongest drive shared by both sexes was thirst, with an average of 20.4 crossings. This, as illustrated in the graph, reached its peak after a deprivation of twenty-four hours. The decline in average number of crossings from that point on is doubtless due to the growing weakness of the rats. Hunger was apparently somewhat less motivating than thirst, with a peak average of 18.2 crossings. Moreover, hunger reached its greatest strength three days later than thirst, a fact which also suggests that it is a weaker drive. The sex motive, with an average of 13.8 crossings for both sexes, was much weaker than the thirst and hunger motives. Its greatest intensity came after twenty-four hours of deprivation for males, and, as we have already mentioned, at the fourth or fifth day of the sexual cycle for females.*

The relative strength of the thirst, hunger, and sex drives suggested by the above data is about what one might expect in view of the fact that men live only a few days without water, a few days longer still without food, and for an indefinite period without direct satisfaction of the sex drive.

* It has been pointed out that a shorter or longer period of observation would change certain of the results shown in Fig. 144. But the maternal drive would probably still be strongest, hunger or thirst next, sex next, and the exploratory drive weakest. There might be some change in the intervals of deprivation at which the peaks for these drives occur.[35]

Those who regard sex as the strongest human drive do so principally on the ground that much human maladjustment has a sexual basis. This association between sex and inability to make an adequate adjustment to the conditions of civilized life does not spring from the physiological urgency of sex alone. It comes primarily from the fact that sex, of all human drives, is most hedged around with moral restrictions. If the tables were turned, with restrictions on satisfactions of hunger as great as those now applied to sex, but with sex satisfied as readily as we now satisfy hunger, one might expect maladjustment to be rooted more in hunger than in sex.

PHYSIOLOGICAL DRIVES, REFLEXES, AND INSTINCTS

The physiological needs of many organisms are satisfied in ways which are characteristic of the species and which individuals do not have to learn. Thus, a male rat mates in approximately the same manner as any other male rat, but in a different manner from that of dogs, cats, or monkeys. Moreover, it mates in the same way — that is, in the same position and with the same sequence and pattern of movements — whether it has observed other rats mate or whether it has been reared entirely by itself. Such complicated unlearned responses are called *instincts.*

Most psychologists now use the term *instinct* in the sense of an *unlearned complex pattern of reflexes.* There has been much disagreement concerning the number of man's instincts. This is largely due to a failure rigidly to define the term *instinct.* Different psychologists in the past used different criteria of instinct. They all agreed that instincts are unlearned or inborn, but from that point on, they differed widely. Instinct for some was any unlearned reaction, regardless of complexity. Thus, the relatively simple response of blinking and the complex

response of walking would be included in a list of instincts. Some psychologists listed only the complex unlearned patterns of reflexes. Others spoke of inborn physiological drives as instincts, regardless of the nature of the culminating responses. In place of "drive" some used such terms as "propensity" or "tendency." Thus the tendencies to construct, collect, fight, and appeal would be listed as instincts regardless of the objects, or the behavior patterns, involved. A few psychologists failed to differentiate between drives or tendencies and behavior patterns, hence their lists of "instincts" included drives, unlearned tendencies, and unlearned behavior patterns. Finally, a few regarded as instinctive any universal drive, tendency, or behavior pattern, the assumption being that, if it is universal, it must be unlearned.

Widespread controversy developed, and hundreds of articles were written on one aspect or another of the "instinct doctrine." Several psychologists even claimed that there are no instincts; that all complex behavior is learned. However, when a differentiation between inborn drives, reflexes, and instincts was finally made, psychologists came to the viewpoint represented by this chapter; namely, that while instincts clearly exist in animals, they are obscured or perhaps absent in man. Even McDougall, perhaps the strongest proponent of instinct, eventually came around to the view that instincts are peculiar to lower animals. He said,

> I recognize that, in the fullest and most universally accepted sense of the word, instinctive action is peculiar to the lower animals, and the extension of the term to the behavior of higher animals and of man has led to unfortunate confusion and controversy which have obscured, rather than elucidated, the true relations between lower and higher forms of action.[36]

The term "instinct" sets off complex unlearned behavior patterns from habits. The terms "instinct" and "habit" do not explain behavior, but they do indicate where explanation may be found. For example, the bird does not fly because of instinct; flying is the instinct. When our observations show that any behavior is unlearned, we know that its explanation resides in the inborn organization of receptor, effector, and neural mechanisms rather than in what has happened to these, as a result of activity, during the organism's lifetime. This inborn organization is to be explained, of course, in terms of heredity and the conditions of early development considered in Chapter 5.

The relation between drives, reflexes, and instincts

We speak of the energizing aspects of behavior as *physiological drives* rather than as instincts, although these drives, like instincts, are unlearned. Drives as such do not determine the pattern of response, for the same drive is associated with different patterns of behavior in different species. The chick that is motivated by hunger pecks, the young mammal that is motivated by hunger sucks, and the older mammal that is motivated by hunger gnaws or nibbles.

As we have seen, the young organism must learn the direction in which activity associated with some physiological needs or drives should be turned. The newborn mammal activated by hunger does not know that food will alleviate its condition. It learns by experimenting, as it were, with various objects, including a nipple. Many responses associated with the satisfaction of needs are relatively simple, unlearned acts like sucking, swallowing, grasping, and withdrawing. These are called *reflexes*. The term *instinct* is thus reserved for relatively complicated unlearned patterns of reflexes.

One cannot, of course, draw the line between reflex and instinct with any degree of precision. One psychologist often lists as instincts some of the responses which another has listed as reflexes. In general, however, an instinct differs from a reflex in being more complicated and in involving an adjustment

of the whole organism rather than some very restricted part of it. Nobody would classify the pupillary response as an instinct, and nobody would classify walking as a reflex. Moreover, instinctive responses are more variable — more attuned to changing conditions — than reflexes.

From what has been said above, one should not assume that every instinct is motivated by a physiological drive. Flying in birds, building of webs by spiders, swimming by fish, and many other similarly complicated unlearned responses may serve any or all of a number of drives. Flying may be motivated by an activity drive, by a hunger drive, by the sex drive, or by a combination of these. Flying may also be aroused when none of these drives is present. For example, the pull of gravity when the bird is launched into the air may automatically initiate the pattern of reflexes which propel it. We can see, therefore, that flying serves no single need. One could argue that it serves no need directly, or that it serves many of them.

It should thus be apparent that, while there is often a relationship between physiological needs, drives, and instincts, the relation is not a simple one in which each instinct serves a particular need or drive. We observe, too, that instincts are elicited under conditions in which no known physiological drive is present.

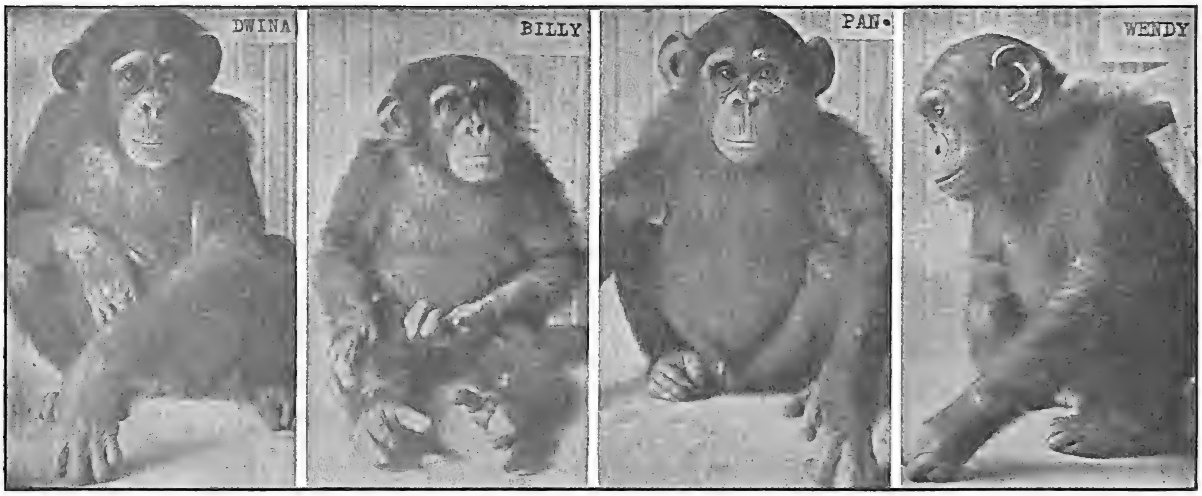
THE SEX DRIVE AND MATING

All of the higher animals have a sex drive. They also have many reflexes associated with sexual functions. But do they all have a mating instinct?

Lower mammals, like the rat, undoubtedly have such an instinct. Consider, for example, a male rat reared in isolation until the age of puberty (two months). It has had no opportunity to engage in exploratory sexual behavior with other rats, male or female, and it has had no opportunity to observe mating in other rats. Soon after it reaches the age of two months, this animal, even with all needs satisfied except the sex drive, becomes much more active than hitherto. This increase in activity, which accompanies the maturity of the testes, suggests that the animal now has a sex drive. But there is no means of satisfying the drive. However, when a female rat in heat is introduced, exploratory activities are soon turned to her. This exploration partly results, no doubt, from the strangeness, to the rat hitherto isolated, of another animal's presence. But it is also because of the stimulating nature of the female's movements and perhaps a typical odor.[37] Within a short period, the male rat exhibits, for the first time in its life, a stereotyped pattern of sex behavior which is very much like that of every other male rat. The mating pattern is approximately the same, regardless of whether a rat has had previous sexual opportunities or has witnessed mating in others. In inexperienced pubescent rats, the behavior pattern is the same as that of older, more experienced rats. The mating pattern in female rats is likewise stereotyped, and it makes its appearance independently of the opportunity for learning it. There is no doubt that the rat, in addition to its sex drive and its sexual reflexes as such, which are obviously unlearned, has an unlearned pattern of behavior with which to satisfy the drive. It has, in other words, a mating instinct.[38]

Mating in monkeys is less stereotyped than in the rat. When the level of the higher apes is reached, it is somewhat doubtful whether a mating instinct any longer exists. The chimpanzee, like the rat, has a strong sex drive, and it has several reflexes associated with sexual functions. But what of the total pattern of sexual behavior, including the copulatory position?

Studies carried out at Yale University with the chimpanzees shown in Figure 145, which were observed from an early age until adulthood, show that mating develops in an exploratory or trial-and-error manner out of



145

Chimpanzees Used to Study Sexual Development

Unlike many lower animals which mate appropriately without prior experience, these chimpanzees acquired a mating pattern only after much exploratory activity, and it was a somewhat different pattern from one to the other. (Courtesy of Dr. Robert M. Yerkes.)

play behavior. The pattern which finally develops, including the position used, differs markedly from one animal to another and in the same animal from time to time.[39]

For obvious reasons, no observations of a similar nature have been carried out with human subjects. However, there is every reason to suppose that learning would be even more evident than in the chimpanzees. Such learning is derived from hearsay, observation and trial-and-error, as well as from direct instruction. The varieties of human sexual behavior are so extensive that sexologists have written volumes about them. Books are also written for the sexual education of newlyweds. If we possess a mating instinct, why should we have to be told the ways in which to mate?

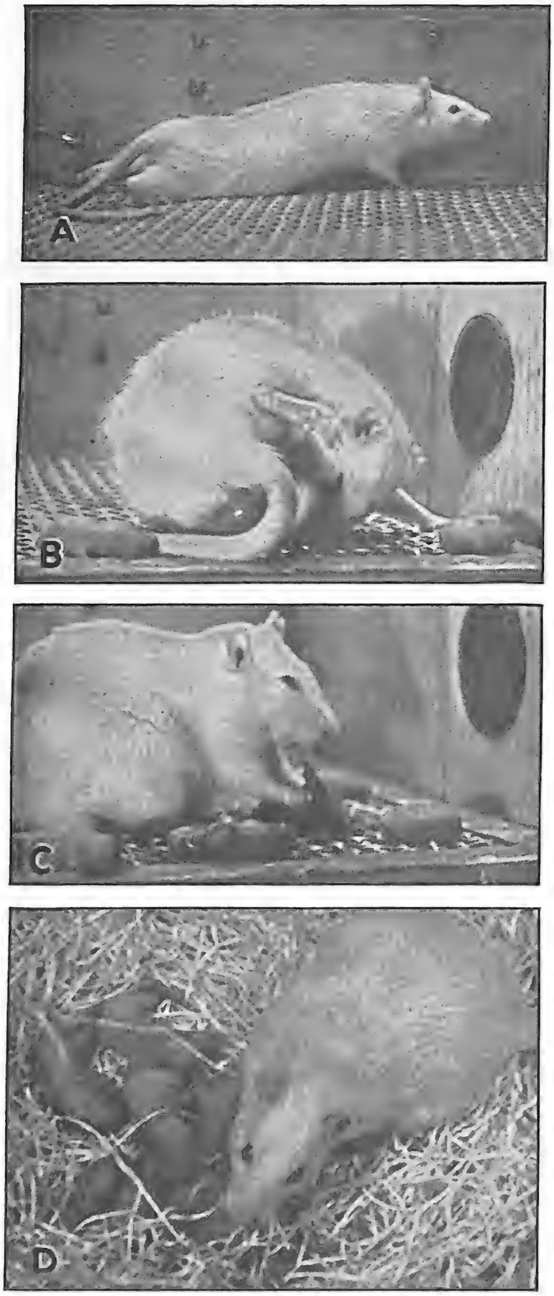
We can conclude, therefore, that man has an unlearned sex drive and unlearned sexual responses of the reflex variety, but that it is questionable whether he has a mating instinct in any strict sense of the word.

MATERNAL BEHAVIOR

What we have said about the sex instinct applies equally well to maternal behavior. The white rat, when she gives birth to a litter, exhibits a clear-cut pattern of behavior even more complicated than the sexual pattern. She licks the newborn, bites off the umbilical cord, eats the placenta, builds a nest out of any debris available, retrieves the young, places them in the nest one by one, and then crouches over them.[40] Some aspects of maternal behavior are shown in Figure 146. Observe the complexity of this behavior, which involves many goal-directed acts rather than a mere series of reflexes elicited by external stimuli.

Prolactin, a hormone secreted by the anterior pituitary gland, plays an important role in motivating maternal behavior in animals. This hormone stimulates even virgin rats to retrieve and care for young rats.[41]

The sequence of responses, with the man-



146 **Some Aspects of Maternal Behavior in the Rat**

A. *Stretching prior to delivery.* B. *Pulling out the placenta.* C. *Eating placenta while young lie around.* D. *With litter in nest. (From Farris, E. J., and Griffith, J. Q., Jr. (Eds.),* The Rat in Laboratory Investigation, *Revised Edition. Philadelphia: Lippincott, 1949, following p. xvi.)*

ner in which they are carried out, is similar from one mother to another. It is just as similar in mothers who have offspring for the first time as it is in experienced mothers. The pattern is essentially the same, whether or not the animal has had opportunities to observe it in others. These facts make it obvious that we are justified in speaking, not only of the rat's maternal drive, but also of its maternal instinct.

Maternal behavior in animals higher than the rat has not been described in any great detail, but it is evident that, as the primate level is approached, maternal behavior becomes increasingly variable. In human beings, neither the maternal drive nor maternal behavior itself is clearly inborn. Prolactin is secreted by the anterior pituitary gland as in the rat, and other physiological conditions associated with birth are quite similar to those found in the rat, but the results of these are unpredictable.

The problem of human maternal motivation and maternal behavior has various aspects which should be kept clearly in mind. There is a great difference between wanting to have children before they are born and wanting to keep them and care for them after they are born. Another aspect of the problem is how the child is cared for. In other words, is there an inborn behavior pattern, as in the rat?

The desire for children is by no means universal. Many women, even after they are pregnant, for various reasons wish that they were not. Prospective mothers were asked, "Are you glad that you are going to have a baby?" More than 75 per cent of the 87 quite frankly said that they were not pleased at the prospect.[42] In another group of 66 expectant mothers, 66 per cent admitted that they had not planned to have a child.[43] Some who became pregnant voluntarily said that they did so only because their husbands wanted a family, because they wanted something to occupy their time, or because they thought it right to have children. These are

only three of the many reasons, apart from mother love as such, which women give for having children.

Many women who say they do not desire children show evident display of mother love after the child has once arrived. However, there are many possible motives other than, or in addition to, the physiological motives.

According to data reported recently there is a close relation between maternal interests and early preoccupation with dolls and babies. Here, for example, are the data for two women, the first rated as "highly maternal" and the second as relatively "non-maternal."

(1) As a young child, her favorite game was taking care of dolls, dressing them, putting them to bed. She played with dolls until age fourteen or fifteen. She used to make visits among her mother's friends to take care of their babies. When she thought of being a mother, she hoped to have six children, and have them as soon as possible. When she saw a pretty baby on the street, she had a strong urge to take it in her arms and hug it. She was a "baby-carriage peeker" before, as after, marriage. In her relations with men she was always maternal; much more, she said, than they liked.

Actually, she had four children and is now pregnant with her fifth. She had a nurse for her first child and was miserable, she said, because she couldn't take full care of it. She hated the hospital rule of not having the baby in her room. She fed all her children at the breast, and with ease. She had a copious supply of milk.

Her husband stated that she really spoiled the children; that every so often she fought against this tendency and became severe, to protect them from her spoiling. But the children "see through it."

(2) Never played any "maternal" games in childhood, nor played a maternal role to another child. She had very little interest in dolls and stopped playing with them when about age six. When she saw a pretty baby on the street, she was not at all interested. As an adolescent, she never indulged in the fantasy of being a mother and having children. She was ambitious to get married, but never thought about having children. As a mother she has felt quite incompetent. She took her children off the breast after two weeks, because she didn't like it; she felt like a cow, she said. She still hates the physical care of children, though she is a dutiful mother and rather affectionate. She never was maternal towards men. Her interests have always been feminine, and she has been quite popular with men.[44]

Some mothers so neglect their babies that the infants, although well fed, suffer from lack of fondling and other attention. According to Ribble in her *The Rights of Infants*, every baby needs a great deal of maternal affection. The fact that so many infants fail to get it, again argues against an inborn maternal drive in women.[45]

What about the pattern of human maternal behavior? There is no universal pattern, unless it be that of feeding the child on the breast when such feeding is possible. Except for this, the pattern differs widely. The way in which children are handled is an aspect of maternal behavior which varies from one culture to another (it is illustrated in Figure 147). There is so much to maternal care besides the nursing pattern, all of it apparently learned, that it is doubtful whether one is justified in speaking of a maternal instinct in human beings. The fact is that human mothers, even with their observations of their own parents and others to help them, are often so ignorant of how a child should be cared for that they must receive special instruction through books or attendance at clinics.

MAN IS PRIMARILY A CREATURE OF HABIT

Insects possess relatively simple nervous systems in which definite functional patterns are laid down. When an insect is stimulated, a discharge of impulses over channels already determined is likely to occur; the result is a stereotyped pattern of response. Few, if any, detours, short cuts, or alternate

A B C

147

Three Contrasting Ways of Handling Children

Studies of cultures other than our own disclose considerable variety in maternal behavior patterns, as evidenced by the different methods used in handling the child. Three methods are shown above. A. New Guinea; the infant is carried on the mother's outstretched arm. (Bateson.) B. Sikkim; the child spends most of its early life firmly fastened to the mother's back. (Gorer.) C. Bali; the baby is carried and suckled in a sling. (Bateson.) (From Carmichael, L., Editor, Manual of Child Psychology. *New York: Wiley, 1946, parts of Fig. 3, p. 681.)*

routes are available. In amphibians, reptiles, and fishes, we find somewhat comparable stereotypy of behavior. Their behavior is stereotyped because the organism has predetermined nervous pathways and connections which shunt nerve impulses going from receptors to effectors over narrowly prescribed routes. Because they are endowed with predetermined behavior patterns with which to satisfy their needs, insects, amphibians, reptiles, and fishes are, from the moment of birth, able to adjust to their environment without help from others. They are not helpless "bundles of reflexes" as is the human infant. In birds, and in lower mammals like the rat, there is less evidence of stereotyped behavior. Nevertheless, innate predetermined behavior patterns are still in evidence. Birds, for example, do not have to learn to fly and, without any training, many build nests which are typical of their species. Rats, as we have seen, exhibit innately determined patterns of sexual and maternal behavior. However, there is less stereotypy in rats than in birds, probably because of the much greater complexity of the rat's cerebrum.[46] Note, too, that rats are much more helpless, and for a much longer time, than chickens. The chicken fends for itself within a few days; the rat only after a week or two. As our study shifts from rat to man, we find that the complexity of the central nervous system rapidly increases. There are fewer complex innate behavior patterns, there is increased helplessness, and there is a longer period of infancy.

The human infant, with its billions of nerve fibers connecting receptors and effectors, is the culmination of this trend away from biological stereotypy. Since it has few predetermined behavior patterns, it is rela-

tively helpless. Until the child develops appropriate behavior patterns, its needs must be attended to by others. Some of these behavior patterns, although absent at birth, are to a large degree determined by the innate structure of the organism. Man cannot fly like a bird, even though he may observe birds and attempt to emulate them. His inborn structures are fitted for crawling and walking, not flying. There is good evidence, moreover, that man's assumption of the upright posture and the general pattern of his stepping movements are also determined largely by inborn structure. The human child, if properly supported, can exhibit stepping movements at birth. Although these movements are not beneficial to the child at an age of general neuromuscular immaturity, they nevertheless provide the pattern for later locomotion. In this connection, the reader will doubtless recall our discussion of maturation (pp. 105–107). There is no doubt that some neural patterns incompletely laid down at birth grow later and that their growth is independent of training.

The only behavior patterns involved in the above-mentioned studies of maturation in human beings have been postural, locomotor, prehensile, and vocal.[47] Although all these are related in general to the satisfaction of physiological needs, none of them is specifically related to the satisfaction of any particular need, as, for example, eating is related to hunger or copulation to sex.

It is apparent that few of the behavior patterns which enable a human adult to satisfy his needs are determined by maturation. They are habits learned during the period of dependency. The primitive child is taught, for example, to spear fish, track and kill game, and fight anyone who endangers his existence. We are taught "civilized" ways of accomplishing the same ends. During the long period of dependence upon his elders, the child customarily learns their way of satisfying physiological needs.

It has been claimed that the infant has many immature instincts, which, because he is not permitted to express them or because his behavior is channelized so early by his elders, never come to expression in pure form. Thus, newborn infants, when placed in a tank of water, make general movements with arms and legs which propel them through the water. This "swimming instinct" is said to be lost by disuse before we ever have any opportunity to swim.[48] Loss of instinct by disuse has been observed in animals. Chicks, for example, fail to peck at single grains after they have been fed and watered by hand in darkness for about two weeks.[49]

Whether or not man has instincts which fail to appear because of disuse or early habit formation, the important fact is that satisfaction of most of his physiological needs depends upon habits acquired from others. We do not know what sort of human behavior would emerge under conditions of complete isolation from others, if such were possible. On the other hand, we know that human needs are satisfied in a variety of ways rather than in the universal stereotyped ways characteristic of lower animals.

SUMMARY

In common with other animals, man has a number of physiological needs upon the satisfaction of which life itself depends. The physiological conditions which are aroused when these needs are not immediately satisfied appear to drive the organism to activity. Activity associated with some physiological drives is initially "blind." For this reason we often refer to it merely as general activity. Under normal conditions, this activity is soon directed toward objects, situations, and the performance of specific acts which satisfy

these needs. These incentives attract the organism, whereas deterrents repel. The latter are associated with negative drives, such as the drive to avoid tissue injury. General activity becomes specific — that is, directed toward incentives and away from deterrents — through the ability of the organism to learn which aspects of the environment satisfy its needs. It learns that certain objects, situations, or acts restore the physiological balance disturbed by deprivation and other injurious conditions. The concept of homeostasis suggests that the organism, through these "restoring" activities, maintains, or attempts to maintain, a constant physiological state. Drive implies merely a "push" from within, whereas motive implies a "push" in some particular external direction, as, for example, toward food, or away from injury.

Food deprivation is followed by an increase of general activity, by spasms of the stomach muscles, and (at least in man) by hunger pangs. Although stomach spasms are often stressed as the physiological basis of the experience of hunger, and of the general activity which follows food deprivation, there is much evidence pointing to a chemical control of activity, stomach contractions, and hunger experiences. The existence of specific hungers, such as for vitamins, minerals, and so on, suggests that the stomach contraction theory is too simple. Blood sugar level has been mentioned as a possible motivator of the other phenomena associated with food deprivation, but the evidence is conflicting.

The sex drive has been shown to depend upon secretions from the gonads (ovary and testis), although the drive is disturbed by injury to the anterior pituitary gland and the cortex of the adrenal glands. In females the most important secretion underlying the sex drive is estrin. In males, it is testosterone. Although the human sex drive has the same physiological motivation as that of other animals, it shows much wider variation both in intensity and in direction of satisfaction. Social influences, such as moral codes and childhood experiences, are important factors underlying such variation.

Water deprivation produces general bodily dehydration which is reflected in a dryness of the mucous lining of the throat and mouth. While this dryness has often been stressed, not only as the physiological basis of the thirst drive, but also as the factor which regulates water consumption, recent research suggests that there is some more subtle mechanism at work.

There are two methods of investigating the relative strength of drives, the method of pitting one drive against another and the obstruction method. Both methods show sex to be a weaker drive than hunger. Investigations with the obstruction method rank the drives investigated, from strongest to weakest, as follows: maternal, thirst, hunger, sex, and exploratory. The strength of the sex drive in male and female rats is approximately the same at its peak, but it is cyclical for females, the peak appearing only on the fourth or fifth day of the sexual cycle.

The expressions of the physiological drives of human beings are so modified by cultural influences that the sex drive, for example, often appears stronger than the hunger drive. It is only under carefully controlled experimental conditions, such as those of the obstruction experiments, that the actual potency of physiological drives can be discovered. Since human beings are creatures of culture as well as physiology, animals provide the only adequate information on the relative potency of physiological drives.

Instincts are complex unlearned patterns of reflexes. We see many instances where animals satisfy their physiological needs instinctively. The mating and maternal behavior of rats illustrates the relations between need and instinct. Flying in birds exemplifies an instinct which does not appear to depend upon any single drive for its motivation. The point was stressed that,

while instincts are often related to particular drives, they are sometimes elicited by any one or more of a number of drives and sometimes, even, when no known drive is present.

As our study shifts from rat to man, we find decreasing evidence of instincts. While mating in the rat is clearly an instinct, developing in the same way even under conditions of isolation, the mating of chimpanzees is not clearly so. When the human level is reached, one observes even less evidence of an unlearned mating pattern. In the case of maternal behavior, it is even doubtful whether human beings have a physiologically determined maternal drive. The specific patterns of human maternal behavior, except possibly for suckling at the breast, are learned.

The decreasing evidence of instincts as we ascend the scale of evolution and the increasing importance of learned behavior may be attributed to the increasing complexity of the central nervous system. As the association neurons of the cerebral cortex increase in number, there are many more possible paths for the transmission of nerve impulses. This means that it becomes decreasingly possible for impulses to travel along narrowly prescribed routes from receptors to effectors. Absence of predetermined modes of adjustment renders the organism helpless. Its dependence upon others for satisfaction of its physiological needs leads to the acquisition of learned modes of satisfaction.

One cannot say what complex patterns of behavior would emerge if human beings could be reared in complete isolation from others until the time of maturity. If any complex behavior patterns were universally present in such isolated individuals, we would call them instincts. As the situation stands at present, we must conclude that man has the inborn physiological drives found in animals, that he has many reflexes, themselves also inborn, but that complex behavior patterns which serve to satisfy his physiological needs are largely, if not entirely, learned. How many instincts might appear if man's behavior were not so early restricted and so early channelized by social influences is of no practical consequence, since he actually lives by habit rather than by instinct.

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12 ACQUIRED MOTIVES

Socialization of Drives • Common Social Motives: Social motives found in all normal human beings; social motives varying with the culture • Personal Motives • Drug Addiction • Life Goals: Many different activities may have a common motivation; predominant motives and specific acts • Levels of Aspiration • Functional Autonomy • Force of Habit • Unconscious Motivation: Post-hypnotic suggestion; unconscious basis of attitudes; slips of the tongue • Incentives and Effort: Monetary incentives; incentives in industry • Interests and Attitudes • Summary

The physiological drives are part of our biological heritage, hence inborn and universal. In other words, we are hungry, thirsty, sleepy, and sexually excited because of our animal ancestry, not because of anything that happens to us as individuals. In the final analysis, most of our motives are related directly or indirectly to the physiological drives. Some have claimed that the energizing of all conduct is ultimately physiological; that if every physiological drive were removed, the organism would be as inert as an engine without fuel or a watch with its mainspring removed. This doubtless is true, but to say that all motivation stems ultimately from our inborn physiological makeup does not help us to understand the great range of human motives which have little, if any, direct or obvious relation to inborn physiology.

When we examine the origin of most human motives, we find their roots in the individual's life history, in what has happened to him. As already suggested, the effects of past experience are recorded in the nervous system. To the degree that these "records" differ, so also do motives. Even the ways in which the physiological drives are satisfied by the higher organisms differ a great deal from one group to another and from one individual to another. To a large extent, their expression depends upon participation in the family as well as in broader social groups.

SOCIALIZATION OF DRIVES

The motives of infants are direct expressions of physiological needs. Activities are guided by the need for food, for water, for sleep, for warmth, to avoid painful stimuli and so on. In order to satisfy these needs, however, the infant must receive guidance from others. He cannot satisfy them unaided. His dependence upon others leads him, eventually, to adopt their ways of satisfying physiological needs. He adopts their ways because he knows no others and because conformity to family and group ways receives positive reinforcement. As the child grows older, his physiologically motivated behavior is increasingly turned toward socially acceptable expressions. His modes of satisfaction are those of his family and of his particular culture. The end result is an individual who, while activated physiologically, finds his satisfactions of physiological needs in accordance with the norms or customs of the groups with which he identifies himself.

We, as grownups, do not eat, mate, and sleep

in any old way, but in certain definite ways, with certain objects and in certain places which are mainly prescribed by our social setting, whatever this particular setting may be. If we are Chinese in China (under ordinary conditions) we may not be quite satisfied with our meal if rice is not included in it. If we are good Catholics, we will not indulge in steaks on Fridays, but will look for smelts, lobster, or other delicacies from the ocean. Under ordinary conditions, any old bed will not do. We want to live and sleep in a certain locality where the people are "nice," or in a hotel on the level with our standards. Similarly with our mates. The steady girl or boy friend, or lasting mate, has to be a person who will not constitute a threat to our social standing in our group, and who has certain socially and personally approved features that go with our values of masculinity or femininity. We may feel utterly frustrated if we do not succeed in joining a certain organization or club, or going to a certain college. We may feel left out if we are not able to wear a certain fraternity or sorority pin. Likewise, our enjoyment of playing golf on a beautiful links may not be so complete if we realize that our next-door neighbor pays a thousand dollars more a year to belong to his golf club.[1]

We acquire hundreds of needs, few of which have very clear physiological roots. It is easy to see such roots in the need for a living wage or for a home, but difficult to see them in the need for jewelry, fashionable clothes, a television set, or a trip to Hawaii. In this chapter we consider a few of the major bases of typically human motivation.

Most of our acquired motives, whether grounded in physiological needs or not, are clearly social in origin. That is to say, they are conditioned by the behavior of other people.

COMMON SOCIAL MOTIVES

Some socially conditioned motives are found in all normal human beings, regardless of race or culture. Others are universal or widespread within a particular culture but rare or nonexistent in other cultures.

Social motives found in all normal human beings

The socially conditioned motives found in all normal human beings are well exemplified by our desire to associate with others. All organisms that are long dependent upon others for survival become greatly disturbed when isolated.

The motive to keep in contact with others is called *gregariousness.* It is so nearly universal in human beings that some have thought it inborn. But life itself, because of the child's helplessness, depends upon the satisfaction of needs by parents or substitutes. Through the process of conditioning, stimuli and activities associated with the satisfaction of needs acquire increasing potency to arouse motivated behavior. To an infant, the mother is at first merely a means of satisfying basic needs. But long before she has outlived her usefulness in this respect, the infant's mother becomes a cherished object of its surroundings. Likewise any others who are closely associated with satisfying its needs develop an attractiveness in their own right. That is, apart from the part that they play in the satisfaction of needs. Most of our physiological needs are normally satisfied in association with other human beings. As one grows older, his group contacts broaden. For example, he learns to enjoy moving pictures in the company of others. Later on, if he has occasion to view a film alone, he may not enjoy it as much as when others are present.

Since we are dependent upon others for a long period of time, and most of our pleasures from the time of birth are experienced in the company of others, there seems no necessity for supposing that our strong desire for human associations is inborn. It seems much more reasonable to suppose that gregariousness is learned. It is learned by all, because all go through a period of helplessness and dependence upon others. Indeed, a term has been coined to represent

these "common modes of learned response that are the products of original nature and commonly shared environment." [2] The term is *coenotrope*. It is derived from two Greek words which mean "common habit."

There would be no point in attempting to list all of the coenotropes.[3] In addition to gregariousness, two good candidates for such a list would be: (1) the tendency to imitate, which most human beings learn because they find it to their advantage to do so, and (2) the tendency to appeal to stronger individuals than ourselves or to superhuman agencies when our own resources fail. Gregariousness, imitativeness, and the tendency to appeal to powers superior to one's self, all have their beginnings in human helplessness and the necessity in early years of being cared for by others. They are of course fostered by literature as well as by face-to-face contacts.

Social motives varying with the culture

Many motives, rather than being universal, are limited to our more restricted cultural group. In our society, for example, most of us develop a very strong drive to assert ourselves, or to get recognition in some shape or form. This has been called the *self-assertive* or *mastery* motive. The motive is expressed in leadership, in self-display, and in a wide range of competitive activities. What is of especial interest to us here, however, is the fact that this motive is absent in certain societies. Among the Arapesh of New Guinea, self-assertion is so rare as to be regarded as abnormal.

> With work a matter of amiable co-operation, and the slight warfare so slenderly organized, the only other need that the community has for leadership is for carrying out large-scale ceremonial operations. Without any leadership whatsoever, with no rewards beyond the daily pleasure of eating a little food and singing a few songs with one's fellows, the society could get along very comfortably, but there would be no ceremonial occasions, and the problem of social engineering is conceived by the Arapesh, not as the need to limit aggression and curb acquisitiveness, but as the need to force a few of the more capable and gifted men into taking, against their will, enough responsibility and leadership so that occasionally, every three or four years or at even rarer intervals, a really exciting ceremonial may be organized. No one, it is assumed, really wants to be a leader, a "big man." "Big men" have to plan, have to initiate exchanges, have to strut and swagger and talk in loud voices, have to boast of what they have done in the past and are going to do in the future. All of this the Arapesh regard as most uncongenial, difficult behavior, the kind of behavior in which no normal man would indulge if he could possibly avoid it. It is a role that the society forces upon a few men in certain recognized ways.
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> Thus, in a society where the norm for men is to be gentle, unacquisitive, and co-operative, where no man reckons up the debts that another owes him, and each man hunts that others may eat, there is a definite training for the special contrasting behavior that "big men" must display.[4]

Among the Zuñi and Hopi Indians, also, marked self-assertiveness is rare. An individual who excels in competitions is prevented from entering further competitions. Zuñi children, when asked to do problems at the blackboard and indicate when they are finished, hold back until all have completed the problems before turning around. Each hesitates to show better performance than another.

Self-assertiveness is rare among the Arapesh, Zuñi, Hopi, and other groups because it is frowned upon by the adults and discouraged. In our own society self-assertiveness is a strong motive because from very early childhood it is encouraged. We want our children to excel and we set an example of self-assertiveness which they cannot fail to observe, and find advantages in copying.

Our restless urge to achieve is interestingly contrasted with the passivity of certain other cultures in the following report of a

conversation between an Indian and a missionary bent on improving the Indian's social and financial status.[5]

Missionary: Brother, why don't you go to the big city and get a job in a factory?

Indian: Suppose I get a job, what then?

M: If you get a job, you will get money and you can have many things.

I: What then?

M: Well, if you do your work well, you will be promoted, become a foreman, and have more money.

I: What then?

M: Oh, then you may become the superintendent of the factory if you work hard enough.

I: What then?

M: If you study all about the business and work harder, you may become the manager of the whole business.

I: Suppose I become the manager, how would that benefit me?

M: If you are an able manager, you can start a business of your own and have more money than ever.

I: Then what?

M: Oh, eventually, you will have so much money that you won't need to work at all.

I: That, paleface, is what I'm doing now. Why go to so much trouble to gain what I already have? The white man has the restless sea within his bosom, but the Indian dreams with the stars and looks on.

Another motive that is prevalent in many societies, including our own, but which is extremely rare in others, is aggressiveness. The motive is most typically aroused by frustration, by hindrance with the satisfaction of needs, physiological or acquired, but it is suppressed or fostered, depending upon the group norms. The Arapesh of New Guinea are a peaceful people who discourage displays of anger and aggression. The Mundugumor, on the other hand, foster aggressiveness, even from the time of infancy. Take the feeding situation, for example. It is one where the child must keep sucking or forego his meal. In this situation,

Children . . . develop a very definite purposive fighting attitude, holding on firmly to the nipple and sucking milk as rapidly and vigorously as possible. They frequently choke from swallowing too fast; the choking angers the mother and infuriates the child, thus further turning the suckling situation into one characterized by anger and struggle rather than by affection and reassurance.[6]

As he becomes older, the Mundugumor male is trained in a manner calculated to fit him for survival in battle. In this training, modes of fighting have a large place.

We see the same sort of parallel between the Zuñi and Comanche Indians. The Zuñis, a pastoral people, expressed their peacefulness, even in their clothing, as illustrated in Figure 148. The Comanches, on the other hand, were noted for their pugnacity. Comanche males were taught to be fighters and they dressed and equipped themselves in a manner suggesting their aggressiveness.

Aggressiveness was once thought to be universal, inborn, and ineradicable. Its alleged innateness was often quoted in support of those who believed war to be inevitable. Today we realize that man is by nature neither warlike nor peaceful. It is true that he has certain physiological needs which demand satisfaction. But if he can satisfy these without hindrance, and he has not been conditioned toward pugnacity by his group, his behavior is characterized by peacefulness. On the other hand, actual or anticipated frustration of basic needs arouses anger and, quite frequently, aggression directed toward the persons or situations responsible. One must not overlook the additional fact that each of us is born into a situation where certain culture patterns, including traditional antipathies, already exist. These may mold us into aggressive or peaceful individuals, regardless of whether satisfaction of our needs is thwarted or threatened with frustration.

There are other common social motives which vary in degree and mode of expression from one culture to another, but we

148

Contrasting Motives as Expressed in Dress

The Zuñi Indians (left) were a passive, peaceful group. The Comanche (right), whose culture was built around war, developed belligerence as a personality norm. (After an illustration in Linton, R., "The Personality of Peoples." Scientific American, *August, 1949, p. 15.)*

shall not attempt to classify them. Our aim in the preceding discussion has been to focus attention upon the fact that specific acquired motives are shared by all normal people and that certain others are shared not by all people but only by members of particular cultural groups.

PERSONAL MOTIVES

Many motives are much more personal than those already mentioned. They are, so to speak, variations on the universal or cultural theme. Thus, while all normal men are gregarious, their gregariousness is expressed in individual ways. Some are satisfied to limit their contacts to family and neighborhood while others crave attendance at clubs or participation in larger social groups. Some are passive in group situations and others active. Some lead and others follow. By the same token, the self-assertive members of our civilization assert themselves in a variety of ways, some in bodily contacts and some through the spoken or written word. Most men seek recognition in limited ways and others are satisfied only with national or world-wide recognition.

Specific goals also differ. Whether their basic aim is to achieve recognition or merely

to achieve security, some men want to be doctors, others lawyers or engineers. Still more individualistic are such motives as the desire to collect stamps, coins or antiques. More individualistic still is the desire to marry a particular person or fill a particular position.

Although such personal motives may at times be traced back to physiological drives and cultural influences, the roots are usually devious and widespread. It often happens that two or more competent psychologists start from the same point and arrive at quite different conclusions concerning the motivation for particular cravings, desires, or ambitions.

The problem of what motivates people to act as they do is also complicated by the fact that motives are strengthened or weakened by outcomes. Quite often we get what we want only to find that it is no longer as appealing as it once was. Sometimes we work toward a limited goal and, after reaching it, acquire many wants that were not present before and which require additional effort. Sometimes, too, motives undergo radical changes — we are converted to new ideals and change our goals accordingly. The following quotation provides a good illustration of some of these complexities:

> A man of great wealth finds that his ruthless business practices have made him an object of hatred and scorn in his country. He grows old, gets religion, and begins to worry about his soul. He needs social approval, and he needs it desperately. On the advice of his friends he hires an eminent public relations expert, who advises our millionaire to become a great philanthropist — to give large sums of money to churches, universities, research foundations, hospitals, libraries, etc. This is done, and gradually the name that was anathema to the public becomes highly respected. But the millionaire continues to give money to the support and expansion of these many institutions. Why?
>
> The answer . . . might be that this behavior is still an attempt to satisfy the "basic" need that was assumed to be initially responsible for his philanthropic gestures or else that through habitual money giving, this behavior has become a "drive." [But] this behavior may be due to *new* needs or demands not necessarily related to the earlier needs or demands. Our millionaire, in giving money to public institutions, has met theologians, scientists, philosophers, writers, doctors — people whom he had not known on intimate terms before. He may have become interested in new concepts; he has been exposed to new ideas, talked with men of strange enthusiasms. All this could very well have altered his cognitive structure, his range of appreciations, and even his personality structure in such ways as to invoke new needs and demands.[7] *

In the following discussions we focus upon a few aspects of these very complex problems of individual motivation. We begin with a form of acquired motivation which has all of the urgency of inborn physiological drives.

DRUG ADDICTION

Some individuals acquire the habit of taking drugs to relieve pain or to escape from sorrow or boredom. Certain drugs may be non-habit-forming in the sense that a craving for the drug as such does not develop, but the use of any drug to escape from reality may lead to dependence upon the drug for that purpose. Many habitual drunkards, for example, have come to depend upon alcohol as a means of escaping the unpleasant realities of everyday life. Certain other drugs are habit-forming in the sense that there develops a "need" for the drug as such. Those addicted to morphine, for example, actually become ill when denied it. Continued use of the drug produces physiological changes in the organism so as to create an artificial need. The "need" is not merely a desire to escape from reality, for animals may also become addicted and ex-

* From *Theories and Problems of Social Psychology* by Krech and Crutchfield. Copyright, 1948. Courtesy of McGraw-Hill Book Co.

hibit physiological and psychological reactions similar to those of human beings.

In one of several investigations of drug addiction in animals, chimpanzees were injected with morphine twice daily for periods ranging up to fifteen months.[8] From about six weeks on, the time differing for different animals, failure to give an injection at the regular time produced physiological disturbances and also behavior suggesting that the animal sought an injection. Restlessness, depression, and other symptoms were apparent. Continued use of the drug intensified such symptoms. When released from its cage at or after the usual time for an injection, the animal took hold of the experimenter, pulled him toward the room where the injection was given, picked up the syringe, gave it to him, and bent over for its injection, which was given in the rump. Here, as in the case of human morphine addicts, there is doubtless an acquired physiological need for the drug. The cure of drug addicts is especially difficult to accomplish, partly because actual illness follows withdrawal of the drug.[9]

Cravings for tobacco, coffee, and tea are mild and apparently harmless, but their origin is similar to that of drug addictions. Failure to obtain these substances, in a person "addicted" to them, is often followed by restlessness and other disturbances. Many a person is "not fit to live with" until he has had his morning cup of coffee.

LIFE GOALS

When we consider motives like the desire to become a doctor, a sailor, a lawyer, a banker, a merchant, or a teacher, the roots spread in so many directions that it is all but impossible to follow them. Every individual's life goal, even when it is shared with others, has somewhat different origins. One may wish to be a doctor because he sees it as a good way to make a living; because his childhood curiosity about bodily functions was never satisfied; because, in his play activities as a boy, he obtained satisfaction out of doctoring other children with the aid of the toy doctor's kit which somebody gave him; because religious teachings have imbued him with the idea of serving his fellow men and he sees the doctor as a servant of mankind; because his pals are going to be doctors; or perhaps for any one of a hundred other reasons. Sometimes a combination of influences like those mentioned underlies one's selection of a life goal.

Many different activities may have a common motivation

It is often apparent, when we investigate a person's life history, that the individual's many different activities have a common theme — are similarly motivated. Sometimes the motive is a desire for recognition, and sometimes it is a desire merely to become self-dependent. The so-called "will to power" is often suggested as the connecting thread.

While personal histories differ in details, most of them suggest that a predominant motive is established in childhood, largely through the influence of social contacts. As the individual gets older, one activity after another may be taken up while others, which no longer contribute to satisfaction of the predominant motive, or which contribute less than the new activity, are dropped.

It quite frequently happens that frustration early in childhood creates a strong desire for recognition, for mastery, or for self-assertion. The aggression of men like Hitler has been attributed to early frustration. Adler has claimed that the frustrations of childhood create in most of us a "will to power." At least it is clear that, if an individual has some predominant motive, like a desire for recognition, it is a "thread" which runs through many different activities.

Predominant motives and specific acts

Many activities other than those related

directly to life goals contribute to satisfaction of a single motive. Suppose, for example, that you are hungry and wish to eat. You perhaps open one door, go downstairs, open another door, walk across the campus, open still another door, walk to a counter, take up a tray, pass down the line, picking up one dish after another, pay the cashier, sit down, and begin to eat. If one asks, "Why did you open the door?" "Why did you cross the campus?" and the like, he gets his answer in terms of the fact that you wished to eat and these acts each contributed to that goal. Each act, meaningless by itself, was meaningful in terms of the motive which predominated at the time.[10]

LEVELS OF ASPIRATION

In choosing life goals and in undertaking everyday activities, individuals differ widely in their level of aspiration — that is to say, in their expectations of accomplishment or in the demands which they make upon themselves. One individual, let us say, aspires to become a cab driver; another a doctor. Some expect to attain a salary of ten thousand dollars per year while others expect to attain only two thousand dollars. Likewise, if you ask individuals how accurately or how quickly they can perform a particular task, some will set for themselves a high level of accomplishment and others a much lower level.

General observation and laboratory investigations show that one's level of aspiration is usually modified from time to time in terms of his success or failure in attaining his goals. Students who aspire to be physicians, but find the premedical requirements beyond them, eventually lower their level of aspiration. Some then aspire to be dentists. One student, known to the writer, aspired successively to becoming a physician, a dentist, and a mortician. The latter occupations are, of course, worth while and necessary, but for one who first aspires to become a physician, they represent a lowered level of aspiration. One value of aptitude testing, to be considered in Chapter 23, is that it facilitates the setting of a level of aspiration which is in keeping with possibilities of attainment. Some of the unhappiest people in the world are college students who, because of insufficient intelligence, consistently fail to meet the standards required, or have exceptional difficulty in meeting these standards. The same individuals would be far happier if their parents had ascertained earlier in their lives the things that they might be expected to accomplish successfully or without abnormal strain. Some of them would then have been encouraged to develop goals along these rather than along educational lines. Many an unhappy student might, under these circumstances, have been a happy mechanic or clerk instead.

Some individuals enter academic work with the goal of getting a B.A. and then entering a nonacademic field. Finding themselves successful beyond their original anticipation, however, they often go ahead to the Ph.D. and become teachers or investigators themselves. In other words, while failure tends to lower the level of aspiration, success tends to raise it.

In many of the laboratory investigations on levels of aspiration, subjects have been asked to indicate what level of performance they will undertake to achieve on a familiar task such as solving puzzles, placing pegs in holes, tracing through mazes, or doing arithmetic problems. They then perform the task one or more times. After this, they are told their actual performance and asked to state their level of aspiration for a further performance of the task. This is continued for a number of trials. Sometimes an individual is not told his actual accomplishment, but is given a fictitious score which he believes to be his own. Sometimes he is told that others have accomplished a particular score on the task. This is to test the significance of social influences. Finally, the dif-

ferences between the levels of aspiration and levels of actual accomplishment are determined. The experimenter then calculates how success or failure in meeting the designated level influences the level of aspiration.

The results of these investigations are not easily summarized. In general, the level of aspiration stays pretty close to actual performance, but there is a tendency for it to remain above rather than below actual performance. There is a tendency, too, for the individual to raise his goal after success more than to lower it after failure. The influence of social factors is suggested by the observation that individuals tend to raise their level of aspiration when told that average performance, especially of a group regarded as inferior, is above their own.[11]

Such findings as these are often closely duplicated in everyday life. This has been revealed by a recent study in which college students reported on incidents in their own lives. Each student wrote a description of three well-remembered incidents in his life — one involving frustration which prevented him from reaching a goal, one involving achievement of the goal following frustration, and one involving attainment of a goal without appreciable frustration. In each instance involving frustration, this was to have been brought about by another person and the goal achieved was to have involved other persons. After the frustrating incidents had been reported, the students were asked to tell the effect of the incident on their level of aspiration. The chief results are summarized in Table 4. It is clearly evident that complete frustration led about twice as many students to lower as to raise their level of aspiration. Success in goal attainment led a very large proportion to raise their level of aspiration.[12]

Levels of aspiration are influenced by the person's attitudes toward himself and by his estimate of his group status. He gains or loses self-esteem as he succeeds or fails to reach his goals and, if the group is directly involved, so as to be a "witness" to his achievements, he feels that he has gained or lost status, or "face." Such self-attitudes have been called *ego-involvements.* A concept of self, with related ego-involvements, probably precedes the setting of levels of aspiration. "The level of aspiration does not seem to appear clearly until the child has formed some conception of his 'self' — until he has developed a sense of 'pride' which he feels must be maintained." [13]

TABLE 4. SUMMARY OF FREQUENCY OF REPORTED SHIFTS IN LEVEL OF ASPIRATION PRODUCED BY EACH OF THREE TYPES OF INCIDENTS *

Type of Incident	*Frequency of Each Shift in Level of Aspiration*		
	Lowering	*None*	*Rise*
Complete frustration	66	36	33
Frustration followed by goal-attainment	15	15	95
Simple goal-attainment	3	17	121

* From Child, I. L., and J. W. M. Whiting, "Determinants of Level of Aspiration: Evidence from Everyday Life," *J. Abnormal and Soc. Psychol.*, 1949, 44, p. 308.

FUNCTIONAL AUTONOMY

Habits originally acquired under the influence of one or more motives may persist, even after these motives have ceased to be operative. It appears that the habits have themselves acquired the status of drives.[14]

Persistence of habits after the initial motive has been satisfied has been called "functional autonomy." This is because the habits, instead of being driven by needs, desires. aspirations, or the like, seem to have become autonomous, self-governing. Some possible examples of functional autonomy are persistence of sexual behavior after the menopause, when estrogens are no longer present; persistence of a vocational activity after the individual has made his fortune and achieved distinction; and "living to eat"

instead of eating to live. Still another possible example would be the persistent giving of the philanthropist whose donations were at first initiated by the desire to achieve desirable group status.

In most instances of apparent functional autonomy there is, as in the case of the hypothetical philanthropist, a possibility that new motives have supplanted the original ones. Even the man who has made a fortune and achieved the utmost distinction may feel that he must keep working so as not to be regarded as a "has been," a "quitter," or one of the "idle rich." Here are ego-involvements again.

In such instances as we have just cited, habits are autonomous from the standpoint of the original motives, but they are not altogether without extraneous motivation.

FORCE OF HABIT

In cases of functional autonomy, as we have seen, the habit is freed from at least its original motivation. Force of habit, on the other hand, is persistence of a particular way of satisfying a given motive. For example, if we satisfy the hunger drive by eating foods prepared in a certain way, there is often resistance to eating foods prepared in some other way. Likewise, if an older person's need for rest and recreation is customarily satisfied by sitting quietly at home, perhaps reading, he may resist the suggestion that he go to a movie or to a bridge party. In other words, habit forces us "into a rut." This phenomenon is often referred to as the "force of habit," as though habits once formed act somewhat as drives, impelling us to continue the accustomed ways instead of taking up new ways of satisfying our motives. The social significance of this tendency for habits once formed to persist is indicated in the following quotation from William James: [15]

> Habit is the enormous fly-wheel of society, its most precious conservative agent. It alone keeps us all within the bounds of ordinance, and saves the children of fortune from the envious uprisings of the poor. It alone prevents the hardest and most repulsive walks of life from being deserted by those brought up to tread therein. It keeps the fisherman and the deck hand at sea through the winter; it holds the miner in his darkness, and nails the countryman to his log cabin and his lonely farm through all the months of snow; it protects us from invasion by the natives of the desert and the frozen zone. It dooms us to fight out the battle of life upon the lines of our nurture or our early choice, and to make the best of a pursuit that disagrees, because there is no other for which we are fitted, and it is too late to begin again. It keeps different social strata from mixing. Already at the age of twenty-five, you see the professional mannerism settling down on the young commercial traveler, on the young doctor, on the young minister, on the young counselor-at-law. You see the little lines of cleavage running through the character, the tricks of thought, the prejudices, the ways of the "shop," in a word, from which the man can by and by no more escape than his coat-sleeve can suddenly fall into a new set of folds.

James may have exaggerated somewhat the permanency of habitual modes of behavior, for people often do change their prejudices and, during war or other emergencies, their ways of living. However, there is strong resistance to change. Anyone who wishes to change the behavior of an adult must take into consideration his tendency to persist in his well-formed habits.

UNCONSCIOUS MOTIVATION

The fact that individuals are not always aware of the motives which underlie their acts is well recognized. Phobias, or abnormal fears of particular objects or situations, often exemplify unconscious motivation.

A Midwestern English professor had, as long as he could remember, an intense fear of going more than a few blocks from his home. This fear was so strong that he had always lived in the same house and within

a narrowly circumscribed area. He did not know the basis for his fear. During the course of psychoanalysis he recalled that, as a child of three, he wandered from his mother over to the railroad tracks. A train coming into the station rushed by and he was scalded by the steam. Although he failed to remember the incident until adulthood, the fear aroused by it had motivated him to stay near his home. The professor's book, entitled *The Locomotive God,* gives an account of the effect of this incident on his subsequent conduct.[16]

A girl had a fear of running water which was so strong that it required the combined efforts of several members of her household to bathe her. Even when she went to school, the sound of a drinking fountain frightened her. While riding on the train, she lowered the curtain so that she would not see streams over which the train passed. The girl, even at the age of twenty, did not know why she acted in this way. However, when she was twenty an aunt whom she had not seen for thirteen years came to visit the girl. The aunt's first words on again meeting her were, "I have never told." This led the girl to recall an accident which she experienced at the age of seven years while walking in the woods with her aunt. The child had promised her mother, when she left, that she would be strictly obedient. However, she ran off from the aunt and, when found, was wedged among the rocks of a small stream into which she had fallen. A small waterfall was pouring down on her head and she was screaming with terror. Her aunt dried the child's clothes and promised that she would never tell the mother of her disobedience.[17]

Post-hypnotic suggestion

Post-hypnotic suggestion provides another good example of unconscious motivation. The subject is hypnotized (see Figure 149) and told that when he wakes up he will remember nothing of what has happened. He is then told that, upon waking, he will perform a certain act. After he is awake, the subject then feels a compulsion to carry out the act suggested, but he does not know why.

A girl (S) in a psychology class was hypnotized in the following manner: She reclined in an easychair and fixated a bright object placed above her head in such a position that her eyes were strained upwards in order to keep it in view. While she was thus fixating the object, the hypnotist (H) said, "Your eyes are becoming tired. Your limbs are tired. You are falling into a deep sleep. You will sleep until I tell you to awake. You will do everything that you are told, but you will remember nothing of this experience. . . ." This continued in a monotone until S's eyelids began to tremble and difficulty in keeping the eyes open was apparent. Then H said, "Your eyelids are trembling. Your eye muscles are tired. Your eyes are closing. They are closing tighter, tighter, tighter. Now you cannot open your eyes. Try, but you cannot open them." S tried to open her eyes, but without success. To make sure that she was not faking the performance, H told her that her right hand was getting numb and that she would soon have no feeling in it. After a few such suggestions, with occasional stroking of the hand, H squeezed up the loose skin on the hand and stuck a sterilized needle completely through it. The subject made no response at all. When H touched the other hand with the point of the needle, it was quickly withdrawn. The right hand was similarly withdrawn from a needle after the suggestion, "Feeling has now returned to your right hand."

Certain, now, that S was deeply hypnotized, H said, "After I have counted to ten, you will wake up. You will then return to your seat and be wide awake. When I scratch my head during the course of the lecture, you will get up from your seat and go to my office, where you will find a laboratory coat hanging behind the door. You will

A B C D

149

Hypnosis and Post-Hypnotic Suggestion

(A) *Normal waking state.* (B) *Trance state, eyes open. Upon command, the subject sits up and opens her eyes, while in a hypnotic trance.* (C) *Abnormal olfactory illusion. The subject smells a glass of water which has been described to him as an exotic perfume.* (D) *Post-hypnotic behavior. The girl, in the trance, is told that upon awakening she will be depressed by pictures on the right-hand pages of a magazine. The boy is told, while in the trance, that the right-hand pictures will be pleasant to him. The girl now refuses to look at right-hand pages, while the boy studies them with interest. (From the film, "Hypnotic Behavior," by Lester F. Beck, and distributed by Association Films, Inc.)*

bring the coat here, into the classroom, and put it on me. I may not want to put it on, but you must get it on me." H then said, "One-two-three — you are waking up — four-five — you are becoming wider awake — six-seven-eight — you are getting wide awake — nine — you are almost awake — ten — you are awake." S opened her eyes, looked a little embarrassed, and returned to her seat. When asked, she said that she remembered nothing that happened from the time she felt her eyes getting tired until

she woke up. H continued with the lecture and, several minutes later, scratched his head. The subject sat still, but looked a little uneasy. However, the lecture was continued. A minute or so later, S, with a great deal of hesitation, left the room. Shortly she returned with the laboratory coat. She said to H, "You had better put this on." H said that he didn't need it. S insisted, saying, "It is rather cold in here and this will keep you warm." H insisted that he did not need it; that the room wasn't cold enough to put it on. S now became very insistent. She tried to get H's arm in the sleeve, insisting, now, that chalk might get on his clothes if he didn't put on his coat. After a few minutes, S began to plead with H to put on the coat. This he finally did. S then seemed greatly relieved and returned to her seat.

When asked why she had done what she did, S said that she didn't know. She said that the idea occurred to her when the instructor scratched his head, but, realizing how silly it was, she decided not to do it. Finally, she could not resist. S said she knew she would feel better if the impulse were followed.

Under the influence of hypnosis, patients have been told that cigarettes will nauseate them, that they will dislike the taste of alcohol, or that they will concentrate better on their studies. The suggested effects are experienced, for varying lengths of time, but the patient usually does not know why he is nauseated by the cigarette, dislikes alcohol, or is so much better able to concentrate on his studies.[18]

Unconscious basis of attitudes

Our attitudes toward other people often have a basis of which we are not aware. The gentlemen who prefer blondes may have had pleasant experiences in childhood while playing with blondes or while being handled by blondes — or, these gentlemen may have been subjected to unpleasant experiences in their associations with brunettes — yet they do not know why they are attracted to blondes more than to brunettes. To take another example of such unconscious motivation, a psychologist reports:

> I met a man named Snyder, and for some peculiar reason felt constantly suspicious of him. . . . I could find no definite reason for disliking him, until one day it occurred to me that a number of years previously I had read a story in which a person named Snyder was a thoroughgoing villain. Having thought of this explanation, all my ill feeling departed and the real Mr. Snyder became a very good friend of mine.[19]

Slips of the tongue

Psychoanalysts, as mentioned in Chapter 1, give especial emphasis to unconscious motivation. Even slips of the tongue, forgetting of appointments, and other simple acts of everyday life are traced to motives of which the individual may not be aware at the moment. Thus, the bored hostess, after an insufferable evening, said, not what she intended (but what she meant): "Well, goodbye, I'm so sorry you came." Likewise, the deb at a dance, much interested in a certain young gentleman, intended to ask him when he was going to dance with her, but instead asked, "When are you going to marry me?"[20] What led a radio announcer in introducing a singer to refer to her as a "charming young sinner" and another to refer to a certain person as "a bottle-scarred veteran"? There is no good reason for supposing that all such lapses are unconsciously motivated — some may be purely accidental — but there is no doubt that many have such motivation.

INCENTIVES AND EFFORT

Incentives are the objects or goals toward which motivated behavior is directed. In a sense we may regard them as inducements to act. In experiments on animal learning,

we offer the animal food, sex, water, a means of escape from punishment, a means of returning to familiar surroundings, or perhaps an opportunity to return to her young. Food, sex, water, and opportunities to return to a more desirable situation are inducements to effort — in other words, incentives. It is perhaps obvious that these are incentives only if the animal is hungry, sexually aroused, or placed in an undesirable situation. To an animal whose stomach is full, food is no incentive at all.

Incentives such as we have mentioned are also effective, under suitable physiological and external circumstances, in arousing human action. In the home, classroom, and industry, however, the incentives used are indirectly, if at all, related to basic physiological drives.

Monetary incentives

Money may satisfy the hunger drive by making possible the purchase of food. Its incentive value then rests upon satisfaction of hunger. On the other hand, people who are not hungry, and who do not need additional money in order to satisfy hunger, are still induced by money to put forth much effort in the performance of various tasks. In some instances they are motivated, not by hunger, but by a knowledge of the fact that money will buy clothes which enhance their attractiveness to the opposite sex. In other instances money has incentive value because it provides a means of gaining prestige, and thus satisfying social motives such as self-assertion and the desire for recognition. This by no means exhausts the motives, physiological, social, or personal, which money may tap. The following table offers an interesting example of the many motives which money may satisfy and, in terms of independent estimates by two groups, the per cent of expenditures allotted to each motive.[21]

TABLE 5. PERCENTAGES OF THE TOTALS OF 33 ITEMS OF EXPENDITURE AFTER ALLOTMENT (I) BY PSYCHOLOGISTS AND (II) BY ECONOMISTS, EXPERTS IN HOME ECONOMICS, ETC.

(Data from Thorndike)

	I	II
Hunger	11.2	11.3
Protection against cold, heat, wet	10.2	9.8
Exercise	.4	.7
Sleep, rest	2.6	2.0
Sex relief	.8	.9
Reproduce species	1.9	.8
Protection against animals and diseases	4.4	4.1
Protection against bad people	2.5	1.5
Reduce or avoid pain	3.5	2.3
Pleasures of taste and smell	4.6	4.8
Pleasures of sight and sound	3.9	5.2
Sex entertainment	3.9	4.1
Security	10.5	11.2
Affection (to get it)	1.8	1.9
Companionship	2.3	2.3
Approval of others	7.2	7.2
Approval of one's self	4.0	3.8
Mastery over others	3.0	1.8
The welfare of others	7.2	8.6
Mental activity	1.9	2.3
Curiosity and exploration	1.8	2.3
Social entertainment	4.2	6.7
Physical entertainment	1.1	1.3
Comfort not in above	4.5	3.0

It is often said that "every man has his price" — that if you offer sufficient monetary incentive you can induce him to do anything that you wish. In line with this idea one psychologist asked college teachers and students how much money would induce them to suffer specific mutilations and to perform certain ridiculous or socially disapproved acts. Some of the representative amounts were $75,000 to lose a little finger, $10,000 to choke a stray cat to death, $100 to become thoroughly intoxicated, and $100,000 to yell out, "The time has come, the time has come," at a church service.[22] It should be recognized, of course, that there may be quite a difference between imagining what amount of money would induce you to per-

form an act, with a full knowledge that the money never will be offered, and actually having the money placed before you. Many a student who said he would require one hundred dollars to swallow a goldfish might, especially if he were "hard up" at the time, perform the act for ten dollars cash in hand.

Incentives in industry

The fact that piece work and bonuses induce workers to put forth increased effort is well known. Introducing such wage incentives often increases the output even of highly skilled workers.[23] However, interests and attitudes aroused in workers toward their jobs, toward the management, and toward each other are often as significant as material incentives.

An experiment carried out at the Hawthorne Works of the Western Electric Company over a number of years seemed to show that increased pay, shorter hours of work, improved lighting and ventilation, rest pauses, and refreshment periods were inducing girls to increase their output of electric relays. Each time a new incentive was introduced, production went up. However, when the girls were returned to the original working conditions, their output not only failed to drop to former levels, but it continued to improve. The conclusion finally forced upon the investigators was that the girls were motivated not so much by external incentives as by increased morale related to the fact that they were selected for the experiment and that the company was apparently interested in them as individuals rather than as mere cogs in the industrial machine. Moreover, common interests and attitudes relating to their experiment gave the girls an *esprit de corps* which went beyond that usually found in industrial situations.

Capitalizing on the findings of this experiment, the company introduced an interview system whereby each employee could air his criticisms to, and talk about personal problems with, a person who would listen and report to the management, but without divulging names. Better morale was thereby introduced because the workers felt that the management was interested in them as persons.[24]

INTERESTS AND ATTITUDES

Interests and attitudes are learned predispositions to react in certain ways to aspects of our environment. A hungry animal is more receptive to food than to other aspects of its environment. Similarly, the student interested in science may be more receptive to physics than he is to English literature; the person who has a negative attitude toward the Democratic Party is thereby more likely to see the platform of this party in an unfavorable light and the platform of the Republican Party in a favorable light. Interests and attitudes thus provide further illustration of the fact that, instead of responding indiscriminately to every stimulus which impinges upon our nervous system, we react selectively — we exhibit personal autonomy or self-regulation.

Interests

Both interests and attitudes predispose the organism to react in certain ways, both are learned, and both may be tinged with feeling and emotion. Interests, however, are always positively directed. We are interested in a person, an occupation, a hobby, or a book. The individual usually likes the things in which he is interested. We would not say that he was interested in something for which he had an aversion. Moreover, interests are usually active rather than passive. We seek to do the things which interest us.

An interest is accompanied by pleasant feeling and by a dynamic tendency to seek the object or do something with it . . . interest in the

movies means that one enjoys attending them and does so. . . . A measurement of one's interests is also a measurement of what one will do, other things being equal. . . . As one does not long continue to like what one cannot do, it is also to be expected that a measurement of one's interests is approximately a measurement of what one can do.[25]

Interests may be acquired in early childhood or later. Some change a great deal with age and some are maintained throughout life. They are usually developed in relation to, and remain allied to, more basic motives. In satisfying his need for activity, or perhaps his curiosity, or both, a child may, for example, play with toy trains, go to the railroad station to watch the trains coming and going, read about trains, and so on. This interest in trains, perhaps begun with a train trip, receipt of a toy train, or the like, may be retained through the years until, in adulthood, the individual finds his career in some aspect of railroading. On the other hand, through fortuitous circumstances, such as receiving a gift of something more enticing than toy trains, moving to a new locality, and being preoccupied with school, the boy's interest in trains may become secondary, or even disappear. He may turn his attention elsewhere.

As suggested in the preceding quotation, an inventory of an individual's interests may point to the vocations in which he is most likely to succeed. This aspect of the problem is considered in Chapter 23.

Attitudes

Whereas interests are always positive in direction, attitudes may be positively or negatively directed. Our attitude toward a political party, a person, a race, a nation, a book, or a movie may, if we have any attitude at all, be favorable or unfavorable. Interests are directed toward specific objects and persons, while attitudes tend to be broader in scope, being directed among other things, toward races, nations, institutions, groups, and general ideas and issues. Moreover, attitudes are more passive than interests. We are more likely to have attitudes and do nothing about them than we are to have interests and do nothing about them. Nevertheless, when we are called upon to make decisions, to act, and to express opinions, our attitudes determine the outcome just as strongly as do our interests. As a matter of fact, attitudes are usually defined as *determining tendencies.*

Attitudes toward races, nations, ideas, institutions, and the like, are sometimes referred to as *prejudices,* because such attitudes lead us to prejudge an issue. Thus, if we are prejudiced against a person who is accused of a crime, we are likely to regard him as guilty, regardless of the evidence; or, if we examine the evidence, we do so with partiality, giving more weight to the damaging than to the exonerating evidence. We can also be prejudiced in favor of some individual or thing. Thus, our country can do no wrong, our children are the most beautiful and best-behaved, and our school is beyond criticism, at least from an outsider. When the word "prejudice" is used without qualification, however, it customarily refers to a negative attitude.

Psychologists have devised scales by means of which an individual's attitudes, and their direction, may be gauged. We have scales for measuring attitudes toward radicalism, the church, evolution, communism, birth control, and races other than our own, to mention only a few. The best-known and most widely used attitude scales are those developed along the lines laid down by Thurstone.[26] Some excerpts from one of these scales, that on *Attitude Toward War,*[27] follow:

Compulsory military training in all countries should be reduced but not eliminated.

The benefits of war outweigh its attendant evils.

He who refuses to fight is a true hero.

An organization of all nations is imperative to establish peace.

War in the modern world is as needless as it is suicidal.

The individual who fills out this attitude blank, containing twenty-two statements like the above, is asked to put a check mark against each statement with which he agrees, a cross against each statement with which he disagrees, and a question mark against those statements about which he is unable to decide. After the individual has filled out the blank, the statements checked are noted and their scale values recorded.

Scale values are determined, while the scale is being developed, by requiring a large group of judges to assign each statement a value from 1 (extremely militaristic) to 11 (extremely pacifistic). Judges are not called upon to say whether or not they agree with the statement, but merely to say, for example, whether the statement, "War in the modern world is as needless as it is suicidal," represents an attitude in favor of or against war, and to assign it a value between the two extreme values of 1 and 11. Each judge assigns a value to each statement selected tentatively for inclusion in the scale. Then, by a statistical method which we need not consider here, the midpoint of the series of values assigned to each statement is determined. Those statements concerning the value of which the judges are in close agreement are selected for the final scale.

The scale values of the statements listed above in order from top to bottom are 5.4, 2.7, 10.6, 7.0, and 9.5. One can see that the first statement, according to the judges, represents a neutral attitude (halfway between 1 and 11). The statement most in favor of war is the second, with a value of 2.7. On the other hand, the third statement, with a value of 10.6, represents a pacifistic attitude.

An individual's score is the middlemost value of the series of values of the endorsed statements. The other statements are ignored. Thus, an individual who endorsed such diverse statements as those used here for illustrative purposes would have the score 7.0, which indicates "strong pacifism." When the number of statements endorsed is even, the two middle ones in the series are averaged.

Attitude scales have many practical and scientific uses. Suppose you represent an organization interested in spreading pacifistic teachings. If you know beforehand which individuals or groups are already pacifistic, you can save your propaganda for the neutrals and the militaristically inclined. Much research has been reported on changes in attitudes resulting from such influences as a college education, change of residence from one part of the country to another (say North to South), various types of propaganda (emotional versus rational appeals), persuasion through the radio or the printed page, seeing moving pictures, or listening to female rather than male speakers. Such changes in attitude are often measured by using comparable forms of an attitude scale, one form given before and the other after the experimental variable has been introduced.[28]

SUMMARY

Some acquired motives are universal because, despite cultural diversities, all human beings are exposed to certain common environmental influences. All are initially helpless, all depend upon social contacts for survival, all are positively conditioned to those who satisfy their early needs, all learn to appeal to others for help, and all learn the advantages of copying certain aspects of the behavior of those around them. Such

similarities of early environment give rise to coenotropes like gregariousness, appealing for aid in time of helplessness, and imitativeness.

Particular motives often characterize a given culture rather than the whole of mankind. Thus the typical American is self-assertive while the typical Arapesh is submissive. Pugnacity and aggression are characteristic of the Mundugumor and the Comanche but not of the Arapesh and the Zuñi. The origin of such motives is found in childhood training.

Motives also vary from one person to another. Thus the self-assertiveness found so predominantly in our culture is expressed in various ways, depending upon the individual. In addition to personal variations in universal or common forms of motivation, there are motives which vary from one individual to another. One may be a drug addict, the other not. One may be addicted to one drug, his neighbor to another. One may be a collector of stamps, another of coins or antiques. One may want to be a doctor, the other an actor. One may want to marry and the other to be a bachelor. Such personal motives are innumerable. Most of them originate in social contacts.

Life goals often have their origins in early experiences. Many different activities have a common motivation. Even the sequential acts associated with short-term goals, like satisfaction of hunger at noontime, derive meaning from their common motive or goal.

Aspirations, while sometimes set for us by our elders without any recognition of our ability to achieve, are usually determined by actual success or failure in relevant activities. Success tends to raise and failure to lower the level of aspiration related to specific tasks.

Some habits appear to acquire the status of drives, or to become independent of their original motivation. This phenomenon has been called *functional autonomy*. It is likely, in such instances, that new motivation has supplanted the old.

Habitual ways of satisfying motives often persist despite inducements to substitute new activities. This persistence is often known as force of habit. It has great significance for society.

Unconscious motivation is illustrated by phobias whose origin is unknown to the person who has them, response to post-hypnotic suggestions, attitudes of obscure origin, and slips of the tongue. The point of our discussion is that many of the motives which markedly influence behavior, as well as the origins of the motives, are unrecognized by the individual whose behavior they influence.

The use of appropriate incentives arouses increased effort in human beings. Monetary incentives are especially important in our society. Knowledge that an employer is interested in one as an individual is an important motivating factor in industry.

Interests and attitudes, although differing in certain respects, are considered together because both predispose individuals to react in different ways to the same external situations. Interests are positively directed, are directed toward specific goals, and are active or dynamic. Attitudes, on the other hand, may be positive or negative in direction, are usually directed toward general situations or issues, and are often more passive than interests. Interests and attitudes may be measured. We have suggested some of the practical and scientific values of interest inventories and attitude scales.

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13 FRUSTRATION AND CONFLICT

Barriers • Conflict: An example of extreme frustration; frustration and goal orientation; aggression as a frustration-instigated reaction • Realistic Reactions to Frustration • Some Common Compensatory Reactions: Identification; fantasy; belittling and blaming; overcompensation • Projecting • Rationalizing • Regression • Repression • Reactions to Experimentally Produced Conflict • Conflict, "Will Power," and Initiation of Action: Conscience; initiation of action • Summary

When one is hungry and dinner is long delayed, he experiences tension, irritability, and perhaps anger directed toward the situation or persons responsible. Hindrances to the satisfaction of hunger and other physiological motives are suffered by all of us. When the frustrating situation is removed and satisfaction of the need occurs, there is a resulting loss of tension and irritability. But each of us experiences situations where obstacles placed in the way of satisfaction are difficult, perhaps impossible, to overcome or circumvent. It is then that the term *frustration* is most appropriately applied. As one clinical psychologist puts it: "*Frustration* occurs whenever the organism meets a more or less insurmountable obstacle on its route to the satisfaction of any vital need. The stimulus situation representing such an impediment may be termed a *stress* and the corresponding distress of the organism may be conceived of as an augmentation of *tension*." [1] The tension (distress) involved is sometimes referred to as *conflict*.

BARRIERS

Barriers are the more or less insurmountable obstacles which interfere with satisfaction of needs. To be a barrier, in the psychological sense, the obstacle must be recognized as such by the person involved. Feeblemindedness, for example, is an obstacle to entering college, but it is not frustrating to the person himself, since he knows nothing of college; nor does he have insight into his own condition, his inability to do what college students do. But to his parents, who know the circumstances, and would like their child to be a college graduate, his feeblemindedness may be frustrating indeed.

Barriers are often non-social, as in the case of floods, storms, and power failures. Sometimes they are social. In other words, people may thwart our aims. A parent requires the child to stay in his room, or forces him to study instead of playing. The child's teacher makes him stay after school. The instructor sets an examination for the day that a student expects to take a trip. The prejudices of his society may restrict a person's companions to those of a particular racial, religious or economic group. They may prevent him from getting the education he desires, or from entering a particular occupation. Psychologically speaking, such factors as we have mentioned are barriers only if the individual is aware of the fact that they impede progress toward his goals.

Somewhat comparable, in effect, are personal defects. These are also barriers which thwart our aspirations. Weakness, size, looks, defective intelligence, poor aptitude

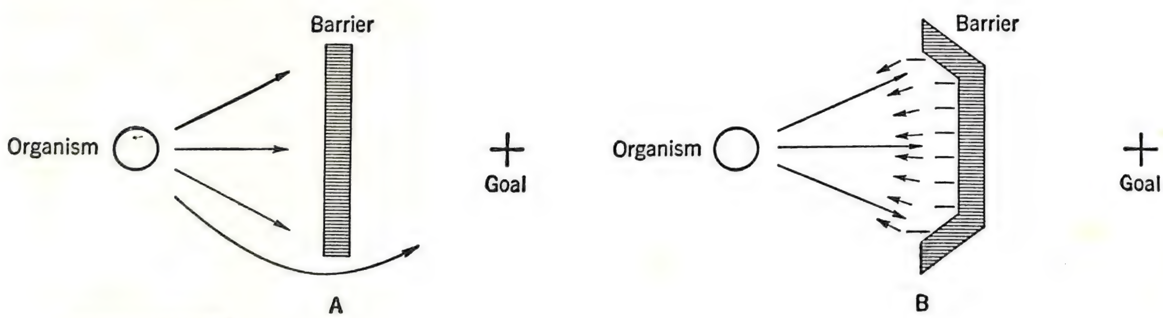
for the job, or an unattractive personality may stand in the way of accomplishment. Deformities may prevent us from engaging in athletics, from following certain occupations and even from marrying. Diabetes or heart disease restrict what we may eat and the nature or level of our activity. The barriers in such cases are more often permanent than those imposed from without.

Both external and personal barriers may be represented diagrammatically as in Figure 150. If the barrier is a readily circumvented one, we represent it as in (A). Here the frustration, if present at all, is temporary. The person detours, thus achieving his goal. But if the barrier is a more or less persistent obstacle, we may represent it as in (B). Here circumvention is assumed to be impossible. The individual either has to give up his goal or suffer continuing frustration.

Objects or circumstances which serve as incentives are sometimes said to have *positive valence*, which means that they "attract" the organism or that he will strive for their achievement. Objects which repel, or circumstances which the individual will work to prevent or obliterate, have *negative valence*. A barrier, standing as it does in the way of goal achievement, may readily acquire a negative valence, even though not previously regarded as repellent. If the barrier is unassailable, or if all routes to the goal necessitate approach to, or acceptance of, negative valences which are more potent than the positive valence of the goal, the goal may be relinquished, or the person may withdraw from the situation, either by running away actually, or by indulging in the fantasy that the barrier does not exist or that it has been circumvented. As we shall observe in discussing compensation, a substitute goal may replace that originally present.

CONFLICT

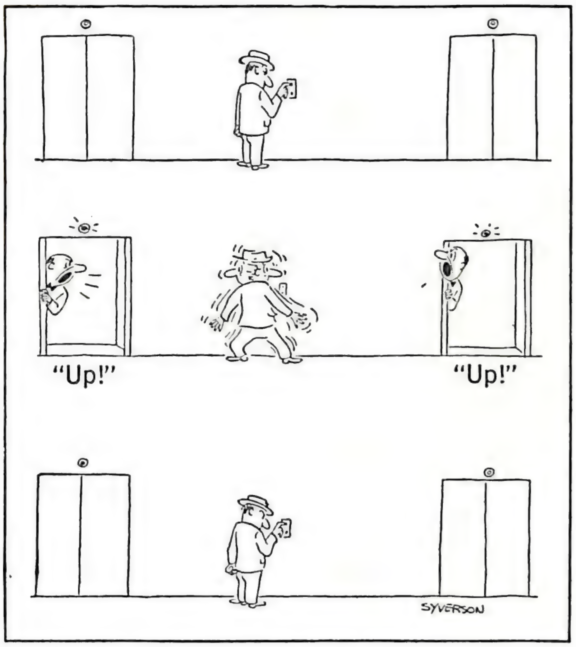
Indecision is also a barrier. This arises in situations where one is unable to choose between equally attractive or equally repel-



150

Barriers to Ongoing Activity

The barrier in either case may be an external hindrance, social or nonsocial, or it may be a personal defect. It could be indecision where conflicting motives, such as whether to marry Mary or Jane, delay or prevent achievement of the goal — in this case marriage. In A we represent a barrier which may more or less readily be overcome or circumvented. The individual is shown as varying his attack upon it until he finds how to reach his goal. In B the barrier is to be regarded as insurmountable. The individual's attacks upon it are of no avail. Negative signs indicate that it requires repelling properties. These may become stronger than the positive attraction of the goal, leading the person to relinquish his goal, to give up his aspirations. (Adapted from Maier, N. R. F., Frustration. *New York: McGraw-Hill, 1949, p. 124.)*



151

Conflict

(From The Saturday Evening Post, *October 1, 1949. Courtesy of the publisher and the artist.)*

ling alternatives. The man in Figure 151, like many another in comparable situations, vacillates between alternative reactions. When no resolution of the conflicting tendencies is achieved, he remains, so to speak, in a state of "suspended animation." The legendary ass, flanked by equally enticing and equidistant bales of hay, starved in the midst of plenty.

Sometimes positive and negative valences balance and suspend action. A boy would like to climb a tree (positive valence) but he is afraid that he will fall (negative valence). If these positive and negative forces are equally strong, the child suspends action. He climbs the tree only after the positive valence has been strengthened or the negative one weakened. Upon reflection, the joy of climbing may seem worth the risk. Or the child may see that the tree contains an intriguing bird's nest. In either event its positive "pull" is increased. On the other hand, the repelling properties of the possible fall may be weakened by the child's reflection that the danger is not so great after all or by provision of such safeguards as having an older person ready to catch him if he falls.*

Comparable situations on an adult level would be refusing a job in which one fears he will fail, remaining a bachelor because one doubts his ability to support his spouse or to make her happy, or turning down an investment opportunity because one fears he may lose his money. In such instances the person may provide himself with some safeguard, thus reducing the negative valence. He may get additional preparation for the job, or for marriage. Or he may obtain adequate protection for his investment.

There are many situations in everyday life where no escape from external or personal barriers, or from conflict situations, seems possible. Sometimes, in such circumstances, the pressures are so intense that a person feels trapped.

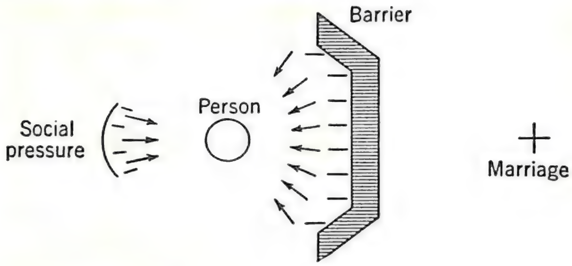
Frustration and the resulting conflict are inevitable aspects of everyday life. Some people can "take it," while others "go to pieces." Those who stand a great deal of serious frustration without breaking down under the stress are said to have a high

* Professor Lewin's so-called "vector psychology" is responsible for the psychological concepts of valences and barriers. He regarded the outcome of situations like those presented here as the resultant (vector) of the attracting (+) and repelling (−) aspects of a situation, *as it is experienced by the behaving individual.* It is perhaps obvious that what repels one person may attract another, and that an attractive (or repelling) situation may vary in the "magnitude" of its valence for different persons. Hence the "forces" concerned do not reside in the physical environment alone but in the environment as the individual perceives it. They are derived from its meaning for him. The "frame of reference" is, in other words, individualistic or personal rather than physical. A very readable envisagement of psychology in these terms is to be found in Snygg and Comb's *Individual Behavior* New York: Harper, 1949.

frustration tolerance, which is defined as "an individual's capacity to withstand frustration without failure of psychobiological adjustment, i.e., without resorting to inadequate modes of response." [2]

An example of extreme frustration

One example from many that we might choose is the case of a man who once came to the writer for aid. Whenever this man became interested in a girl, his widowed and wealthy mother, who had encouraged financial dependence upon her and who had a heart condition, threatened to withdraw financial support. Without such support, marriage seemed impossible. Since the mother also had an aggravation of her heart condition at such times, the son felt that going ahead with marriage plans would perhaps kill her. He was in his forties. Crises of the nature described had been recurring for years, in each instance causing him to reject marriage. His desire to marry persisted, but so, also, did the seemingly insurmountable barrier. The mother continued to use her illness as a device to keep her son nearby and as a weapon to prevent him from getting lucrative employment. The son said he was trapped. Despite intense hatred for his mother, he could not bring himself to leave her, to thwart her wishes, or to do anything which might, as he said, make him feel for the rest of his life that he had been the cause of her death. This problem could be solved, apparently, only by the death of the man's mother or by her re-education. The latter seemed, at the time, hopeless. The man was advised to get married despite his mother. The suggestion that she would probably survive and that she would eventually become reconciled to his marriage did not seem convincing to him. His mother could not, so he said, do without his aid and companionship. He could not be near her and married too. Moreover, she had arranged to disinherit him if he married against her wishes. Her death as a result of his marriage would thus leave him penniless.



152 **Situation Involving Extreme Conflict**

The barrier (in this case a man's mother and his attitudes) remains fixed and insurmountable. The goal (marriage) also remains. Without social pressure the son might evade the issue, going along with his mother's wishes. But with this pressure he is forced to do something — marry, with a resultant loss of his income and possibly of his mother; or not marry, with the resultant loss of standing in the community and of self-respect. The pressure is also negative in valence, because it forces him in the direction of unpleasant alternatives. (Diagram adapted from Maier, N. R. F., Frustration. *New York: McGraw-Hill, 1949, p. 127.)*

One will recognize that the barrier here was not the mother alone. It included the attitudes that she had implanted in her son.

Had the son become so involved with a girl that he was obligated to marry her, or impelled by the pressure of public opinion to do so, and the maternal barrier remained, he would then have been in the plight represented in Figure 152. He would have had to choose between the conflicting alternatives.

It is in frustrating circumstances like these that the term *conflict* is most clearly applicable. The individual is, so to speak, "between the devil and the deep blue sea." His distress is often acute.

Frustration and goal orientation

When frustrated most people retain their

goal orientation, attempting to discover a way out of their predicament or some means of diminishing their distress. Even extreme frustration, like that suffered by the man whose case we have just considered, often fails to disrupt goal orientation. In many instances, however, the individual becomes panic-stricken and his acts defeat rather than further his aims.[3] Then he may "vent his spleen" on innocent people. He may even commit suicide.

Aggression as a frustration-instigated reaction

Aggressions, of which lynchings and wartime atrocities are extreme examples, stem from frustration. Whether or not they serve any purpose, from the standpoint of the aggressor, is controversial. Aggression against innocent persons certainly solves no problems, but it may, of course, serve to release pent-up tensions in the aggressor. Even when this is so, aggression is hardly justified. The man who turns upon his child or his subordinates when frustrated by his wife, against whom he dare not aggress, may feel better, at least temporarily, but he has done nothing to solve his problem. Nor has the perpetrator of atrocities against individuals or groups. If anything, he has erected new barriers, the enmity of his victims and those who sympathize with them.

Whether frustrations are mild or of great intensity, a realistic goal-seeking approach is alone commendable. One should recognize that he is confronted with a problem to be solved and he should use all of the resources at his disposal or seek competent advice in an effort to overcome the obstacles. Certain realistic reactions to frustrations such as we have described will now receive our attention. Some compensatory reactions and subterfuges commonly found under frustrating conditions will then be considered.

REALISTIC REACTIONS TO FRUSTRATION

The most direct reaction to frustrating external conditions is to remove or get around them. It involves trying out various procedures which might occur to us until one of them succeeds or until we are forced to give in. This may be an overt trial-and-error process or it may involve insight and reasoning.

Frustration from personal defects may be dealt with in a similar fashion, especially where the defects are remediable. One could not change his intelligence nor repair the ravages of polio by a problem-solving approach, but he might, if he knew it to be the source of his frustration, change some aspect of his appearance or behavior. Many girls make themselves more attractive to the opposite sex by experimenting with this and that cosmetic, this and that coiffure, or this and that type of dress. Some colleges now have courses designed to help the less attractive girls overcome their deficiencies.

The chief difficulty is that many individuals thwarted by personal defects do not realize the source of their trouble and quite often their friends hesitate to make any suggestions. As we shall point out in more detail shortly, those with personal defects are often ready to attribute their difficulties to almost anything else than to the defects in themselves.

When conflict comes from incompatible motives, a direct problem-solving attack may also be helpful. If one does not know whether he should prepare himself to be a teacher or a salesman, or whether to do his major college work in sociology or in psychology, he can at least gain as much relevant information as possible about these alternatives and perhaps also try his hand in each field.

Then, too, he may list the pros and cons and see where these seem to lead. Benjamin Franklin recommended this method in a letter to Joseph Priestly.[4] He said:

In the affair of so much importance to you, wherein you ask my advice, I cannot, for want of sufficient premises, advise you *what* to determine, but, if you please, I will tell you *how*. When those difficult cases occur, they are difficult, chiefly because, while we have them under consideration, all the reasons *pro* and *con* are not present to the mind at the same time; but sometimes one set present themselves, and at other times another, the first being out of sight. Hence the various purposes or inclinations that alternatively prevail, and the uncertainty that perplexes us.

To get over this, my way is, to divide half a sheet of paper by a line into two columns; writing over the one *Pro* and over the other *Con*. Then during three or four days' consideration, I put down under the different heads short hints of the different motives, that at different times occur to me, *for* or *against* the measure. When I have thus got them altogether in one view, I endeavor to estimate their respective weights; and where I find two, one on each side, that seem equal, I strike them both out. If I find a reason *pro* equal to *two* reasons *con,* I strike out *three*. If I judge some two reasons *con* equal to some *three* reasons *pro,* I strike out *five*; and thus proceeding, I find where the balance lies; and if after a day or two of further consideration, nothing new that is of importance occurs on either side, I come to a determination accordingly. And tho' the weight of reasons cannot be taken with precision of algebraic quantities, yet, when each is thus considered separately and comparatively, and the whole lies before me, I think I can judge better, and am less liable to make a rash step; and in fact I have found great advantage from this kind of equation, in what may be called *moral* or *prudential* algebra.

When conflicts are not resolved in the direct way already suggested, various indirect reactions or subterfuges are often utilized. These are goal-directed, in that they seem to alleviate or to solve the problem. Some have been called *ego-defensive* or *compensatory,* since they defend the person's self-esteem (his ego) in situations where, without such defenses, he would be forced to admit ignominious failure. The goal of much behavior, anyway, is not so much some aspect of the immediate situation as it is the enhancement of self-esteem which comes with mastery. Ego-defensive functions are similar, on a psychological level, to the compensatory reactions referred to in physiology as *homeostatic.*

We have already used the term *homeostasis* (p. 259) in discussing compensatory aspects of physiological drives. Now psychologists use this term to represent the psychological compensatory reactions aroused when self-respect is threatened. One psychologist prefers the term "auto-correctivism," which means the same thing.

SOME COMMON COMPENSATORY REACTIONS

The term *compensation* is most often used in psychology to refer: (1) to emphasis of a different motive when expression of one is blocked or (2) the substitution of one means of expressing a motive when another more direct means of expression is not possible. In both instances we have substitution — either of another motive or of a new form of expression of the same motive.

As an example of the first type of compensation we may take the man who, because his sex motive is thwarted, emphasizes strenuous athletics, or the unattractive girl who emphasizes scholarship.

Examples of the second form of compensation are found in the woman who desires children, but is unable to have any of her own, hence enters kindergarten work; the business man who, after having a morning scrap with his wife in which he couldn't answer back, takes it out on his employees; the individual whose desire for new experience is thwarted except when he reads a novel, or, better still, goes to the movies — where he can, vicariously at least, crawl on his belly through the jungles of Bataan, man a machine gun on the deck of a plunging

battleship undergoing air attack, or carry on a flirtation with Dorothy Lamour; the parent who, unable to have a college education himself, makes sacrifices so that his son can go, and then experiences vicariously all of his son's failures and successes; the man who, in a gabby world, finds joy in belonging to a secret society, or, in a humdrum world, can join a lodge and be a Thrice Exalted Knight of the Enchanted Realm; or the man who in his daydreams finds riches which compensate for actual poverty. All of these are examples where one expression of a motive is blocked, but another expression serves, in some respect, the same purpose.

Two processes which we have suggested but not mentioned by name often play an important role in this latter form of compensation. One of these is *identification,* the other *fantasy.*

Identification

The man who satisfies his desire for new experience by following the hero of a novel or movie, and the parent who experiences the successes and failures of his child as though they were his own, are *identifying.* We say that the individual identifies himself with the character in question. People often have palpitation of the heart, weep, grimace, and even cry out when identifying with characters in movies or on the stage. Sometimes identification is with an institution rather than with an individual. Thus a certain low-paid and academically frustrated instructor in a very large university got compensation out of the fact that he was connected with a university having many thousands of students. The bigness of the institution in which he taught was, for him, the only consoling aspect of his predicament. It bolstered his ego where his academic rank and his salary did not. Membership in a certain fraternity, lodge, or other organization having great prestige often serves a similar function. The member feels himself a better, more successful person, because of his affiliation.

Fantasy

Fantasy may also be compensatory. This process, as one will recall from our discussion of reasoning, is involved in dreaming (day or night) where we go through certain acts in imagination.[5] A good illustration occurred in Charlie Chaplin's film, *The Circus.* The situation was somewhat as follows: Charlie was in love with the girl on the flying trapeze, whose partner — a very big and hefty fellow — was his rival for her affections. Charlie is sitting in the tent watching the performance. Suddenly we see a ghost-like Charlie emerge from the real one, go up to the rival, knock him out, and walk off with the girl. But the man actually begins to descend from the trapeze. As he does so, the shadowy Charlie recedes into the real one, who slinks away despondent.

Fantasies become dangerous, from the standpoint of mental health, when they lose contact with reality by dealing with desires impossible of fulfillment; when they involve impractical solutions; and when they are continually substituted for the real thing, thus preventing an actual adjustment. Mental hospitals contain thousands of individuals whose dreams "have come true" to them. They have, as we say, "escaped from" or "lost contact" with reality. Among these are to be found "great inventors," and such characters as "Jesus Christ," "Joan of Arc," and "Queen Victoria." The writer has even seen a "Clark Gable."

Belittling and blaming

Two other kinds of compensatory activity are associated with attempts to maintain self-respect in the face of failure. One of these is *belittling others,* and the other is *blaming others.*

The person whose ego is badly deflated often inflates it, so to speak, by thinking of

or pointing out the faults of those who have succeeded where he has failed. Thus, the girl who fails to get into a sorority may point out that those who do so are a lot of handshakers, that they think more of politics than of scholarship, or that they are too cliquey a bunch anyhow. This makes her feel a little more happy with her lot. It may go to such an extreme that she is "glad" she didn't get in with such a bunch.

Students who fail courses, for example, often say that they had a "punk" teacher, that the text was beyond comprehension, or that their class came at a bad hour. Sometimes they are right. In the majority of instances, however, such students are attempting to maintain self-respect at a high level by refusing to recognize their own faults. A student once said that the writer's chief weakness was an inability to make up exams that students like her could pass.

Blaming others is a dangerous reaction. Like excessive unrealistic day-dreaming, it may lead to insanity. Mental hospitals contain many people who place responsibility for their troubles upon others. They accuse others of putting ground glass in their food, of poisoning them, of throwing radio waves on them, and of perpetrating other criminal acts. It is apparently easier for them to do this than to admit their own shortcomings and correct them.

Overcompensation

Several forms of compensatory reaction have been indicated, but there remains another important reaction usually called *overcompensation.* Like other compensatory phenomena, this is associated with efforts to overcome threatened inferiority or threatened loss of self-respect. It is associated especially with conflict due to personal defects. As the name implies, overcompensation is a tendency to do more than remove the defect. The former weakling who does not stop when he has developed a normal body, but strives to become the "World's Strongest Man," is overcompensating for his original defect. Theodore Roosevelt and Helen Keller exemplify people who more than overcame their physical defects. Louise Baker's *Out on a Limb* [6] is an interesting account of how one girl, who lost a leg in childhood, made herself a one-legged celebrity. At the end of this biographical account of her life the author implies that, if she had possessed two legs, she would have had nothing interesting to write about. Many "ugly ducklings" have become great actresses, and many people of small stature (Franco, Mussolini, Napoleon — to mention but a few) have become dictators or great military leaders. Many of the radicals in politics are obviously overcompensating for feelings of inferiority. A book dealing with psychology in politics traces the radical tendencies of several such individuals to childhood frustrations.*

A form of overcompensation, but in reverse, is *self-repudiation.* The individual says, "Oh, I'm terribly dumb," "You know, I'm awfully homely," or, "I'm just not good for anything." The answer they desire is, "Of course you're not dumb," "I think you're beautiful," or "You may not be able to cook, but you're a sweet little woman just the same." In many such instances the individual does not really feel inferior, but is merely "fishing" for compliments. He is rudely disappointed if the other person says, "That's right, you are dumb."

When self-repudiation develops to an extreme degree we find people accusing themselves of sins, which they may or may not have committed, and spending much of their time weeping and wailing. The writer knew one old lady who said sin had caused her to "lose her soul." She repeated over and over, "Lost my soul, lost my soul, lost my soul." She regarded any effort to keep alive as a sin, so she would not eat or drink. Only

* Lasswell, H. W., *Psychopathology and Politics.* Chicago: University of Chicago Press, 1930.

forced feeding by means of a tube kept her emaciated body alive. Such individuals stoutly maintain their sinfulness in the face of all attempts to show that, after all, they are no more sinful than most people. Some seem to enjoy the unique distinction of being "the greatest sinner of them all." Such individuals get more attention and recognition than they would enjoy if they were normal. This is undoubtedly the motivation in many cases of self-repudiation.

PROJECTING

Projecting is somewhat like the reactions already considered, in that it often has a compensatory function. We project whenever we attribute our thoughts or desires to others.

Projection is very often an indirect wish-fulfillment. Thus, the girl whose desire for response from men is frustrated may imagine that men have designs upon her. A college girl once known to the writer accused men of chasing her while she went home through a park. Upon investigation, however, it became apparent that she had not been chased. As the psychiatrist put it, "She wished that men would chase her, the wish was father to the thought, and her imagination got the better of her."

Projection sometimes comes from feelings of guilt. If one has done something of which he is ashamed, he may imagine that people have found it out, and he may see relevant significance in their actions. A person who "felt like spitting on himself" got the idea that men whom he passed on the street wanted to spit on him. A girl who was told, under hypnosis, that she had stolen some money was very depressed when awakened. She did not know why. When shown and asked to comment about two men in a picture (Figure 153) she saw one as sad and the other as reprimanding him. Later she said that the boy sitting next to her stole the money. She was obviously projecting her own depression and her own guilt.

In an experimental study of projection, fraternity brothers rated themselves and each other. Such traits as stinginess-generosity and bashfulness-forwardness were rated. Subjects who failed to see themselves as others see them — who were relatively lacking in social insight — showed a marked tendency to rate others as they rated themselves. If one of these rated himself high on stinginess, for example, he rated others high on this trait, if he thought himself generous, he attributed generosity to others.[7]

Indeed, a person who feels guilty often lessens this feeling by imagining that others are guilty too. For example, the married woman who carries on a flirtation may accuse her husband of unfaithfulness, and the college student who cheats may say that his fellow students cheat when they get a chance to do so.

Like some other reactions already mentioned, projecting may lead to mental illness if carried to extremes. Many inmates of mental hospitals are there because they attribute their desires, their thoughts, and even their acts to others. One man said that his every act (even crime) was the "will of God." Another had shot at a girl whose impending marriage was just announced. He did this because, for the year or so that they had been passengers on the same streetcar, she "had deceitfully led him on by her actions." The girl hardly knew of the man's existence and had never given him any reason for his accusations, but her acts had been interpreted as having amorous reference to himself. One will doubtless recall, in this connection, our discussion of direction in thinking and how getting the wrong direction may lead to delusions (see p. 238).

RATIONALIZING

Rationalizing is faulty, defensive thinking motivated by the desire to retain self-respect. It serves this purpose, at least tem-

153

An Example of Projection

Use of pictures which the individual interprets is called a "projective" technique because what is perceived, in this case the sadness of the man sitting down and the accusing attitude of the man standing up, is a projection of personal attitudes. Different people give very different interpretations of the same picture. This technique is considered more fully in Chapter 24. (From the sound film "Unconscious Motivation," prepared by Lester F. Beck, and distributed by Association Films, Inc.)

porarily, by enabling us to avoid facing issues and to excuse our failures. Rationalizing often takes the form of "kidding oneself" as to the real motives for conduct.

Perhaps the most common kind of rationalizing is the attempt to justify decisions or actions by finding "good" reasons for them. A student knows that he should study, but wants to go to the movies. He resolves the conflict by telling himself that too much study will ruin his eyes, that he needs a rest anyhow, or that he'll be able to study even better the next day. Likewise, a married man who carries on affairs with other women than his wife saves his self-respect by concluding that "man is by nature polygamous" or that his wife doesn't really appreciate him anyway. Why doesn't he tell his wife about his unfaithfulness? If he did so, "she would feel unhappy" and "what she doesn't know won't hurt her." The individual responding in terms of post-hypnotic suggestion (p. 297) finds many excuses for carrying out the suggested act, the real motive for which is not known to him.

The girl who says, "Oh, I didn't want that

man anyway — he'd perhaps have turned out no good," or, "Who'd want to join *that* sorority?" is belittling others, but she is also rationalizing. This form of rationalization is very appropriately designated a *sour-grapes* reaction. It is obviously compensatory, since it eases the sting of defeat.

Rationalizing often begins at an early age. A three-year-old who did not want a neighborhood child of five to visit him because this child monopolized his "fire engine" was told that he must invite the other child to come over and have a ride. He said that the other boy might be having his nap. When told that the other boy was up, he said the sky looked as if it might rain. When he was told that it would not rain, he said that the boy's mother might not want him to come. He made one excuse after another, and never did get around to giving the child an invitation.

A child confronted by the alternatives of taking his teddy bear to school and being thought a "big boy" did not take the bear, but his excuse was that the bear might get a cold.

It is probable that children acquire this tendency to rationalize by copying patterns of rationalization set by adults. The "sour-grapes" pattern is obviously copied, for parents frequently tell a child, when they do not wish him to have something, that it is "no good," that it will "make him sick," or that boys who play with such things are "sissies." It seems only natural that, when frustrated under similar circumstances, he should tell himself things like these his parents have told him.

Rationalization is so prevalent a reaction to situations involving conflict that it cannot be regarded as abnormal. It is sometimes excused on the ground that it reduces the qualms of conscience or misgivings which all of us suffer from time to time. Some assert that "if we did not rationalize, we'd go crazy." There is at least a grain of truth in such assertions, but they are themselves largely rationalizations. There is no good substitute for facing life squarely and meeting difficulties realistically.

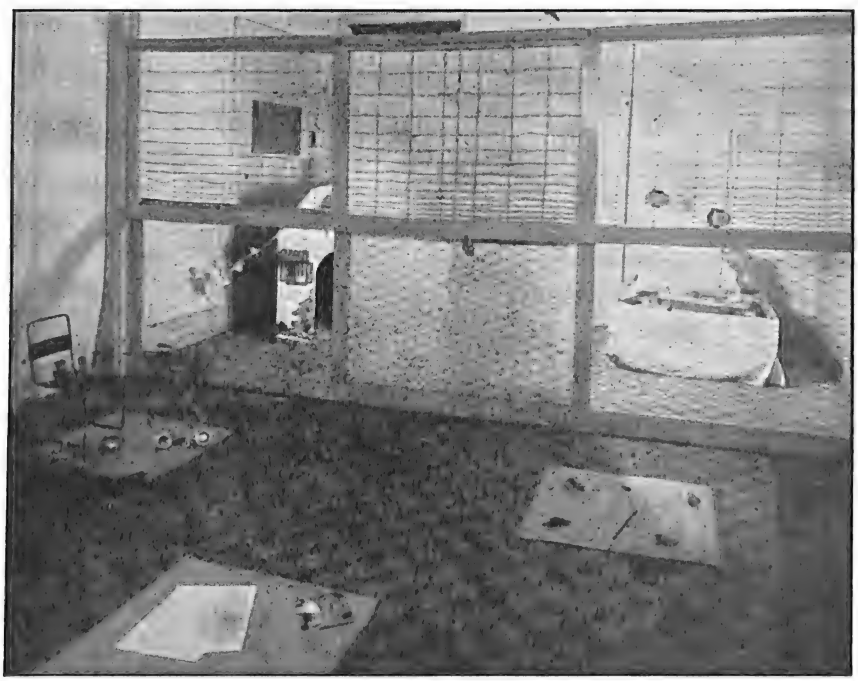
REGRESSION

Whenever an individual confronted by difficulties "gives up" and reverts to such inadequate reactions as weeping, kicking objects around, stamping his feet, and even "cussing," he is regressing to an earlier, less adequate mode of reaction. These reactions perhaps release tension — help us "let off steam" — but they seldom solve our problems. We say "seldom" rather than "never" because many a child learns that temper tantrums, sulking, and the like get him the things he desires. He may, in fact, continue to use these long after adequate modes of adjustment are possible. Men and women often revert to these earlier responses when frustrated. Wives sometimes dominate their husbands, and husbands their wives, by fits of sulking, weeping, and threats that they will "do away with themselves" or "go home to mother" if they do not get their own way.

Psychologists have carried out several experimental investigations of regression in animal and human subjects. Emotion-provoking stimuli like electric shock, a cold shower, and a sudden loud noise presented just before the moment of response lead many subjects to revert to earlier, less adequate forms of adjustment.[8] One study utilized an apparatus like that already illustrated in Figure 66. There were two groups. Members of the experimental group were placed in the apparatus one at a time and given a continuous shock through the floor. The rats soon found that, if they sat quietly on their hind legs and held their forepaws off the floor, they received comparatively little shock. Eventually all of the experimental animals held this position, with occasional random activity, until the shock went off. The duration of the shock was fifteen minutes. We may designate assump-

tion of the above posture as habit 1. Members of the control group were not given an opportunity to acquire habit 1. After a member of the experimental group had learned habit 1 it was placed in the same box, but now containing a pedal, pressing of which terminated the shock. The rats soon learned to give up habit 1 in favor of this much more adequate response, designed habit 2. The control group also learned habit 2. Both groups, in fact, were trained until they had acquired equal efficiency in escaping shock by pressing on the pedal. The crucial part of the experiment came when the pedal itself was electrified, so that it administered a strong shock until pressure was applied. This brought considerable conflict. The subject could still terminate shock by pressing the pedal, but touching it brought a strong shock in the forepaws. Under these conditions, four out of the five experimental rats regressed. That is, after contacts with the electrified pedal, they returned to habit 1, crouching on the floor but not pressing the pedal. All of the control rats, on the other hand, continued to press the pedal.[9]

Children also exhibit regressive behavior when frustrated. The play activity of thirty preschool children was studied before and after a frustrating situation had been introduced.[10] The children were observed individually. Free play was observed, frustration was introduced, and play was again observed for a period comparable in length with the first. The situation is illustrated in Figure 154. During the free-play period,



154 **A Frustrating Situation Which Elicited Regressive Play Behavior in Preschool Children**

The screen, padlocked in the center, prevents a child from returning to the exceptionally attractive toys on the other side. His play with the toys in the foreground is now less constructive than it was before he knew about the more desirable toys, now seen but inaccessible. (From Barker, R. G., Dembo, T., and Lewin, K., "Frustration and Regression: An Experiment with Young Children." University of Iowa Studies in Child Welfare, *1941, vol. 18, p. 57.)*

the child did not know of the farther room, since it was hidden by an opaque partition. After the free-play period, the partition was removed, disclosing the rest of the room. The child then spent fifteen minutes playing with the very enticing objects now displayed for the first time. These included a doll's house with accessories of all kinds, a truck and trailer, a picnic table with accessories, and several other toys. After the child had played with these, it was returned to the other side of the room, with the less interesting toys, and the screen illustrated was lowered. Now the child could see the desirable objects, but the screen and a large padlock made them inaccessible. Two observers, one inside the room and one outside, but viewing it through a one-way vision screen, recorded the play activities. These were later scored in terms of constructiveness. Under free-play conditions before frustration, the average constructiveness score was 4.99. During frustration it dropped to 3.94, a change of 1.05 points which statistical analysis indicates is not due to chance. Of the thirty children, twenty-two regressed to the less constructive level, three did not change, and five increased their constructiveness.

REPRESSION

Some people react to conflict situations by refusing to admit the existence of difficulties, of defects, or of particular motives. These people are said to be repressing. A jealous child who refuses to admit the existence of his baby sister is repressing. So also is the person who has conveniently forgotten some unpleasant obligation.

Repressing is not merely inhibiting, although one may, in repressing, inhibit unpleasant thoughts. A clear case of inhibiting occurs when you decide to study instead of going to a movie. We may say that you inhibit movie-going activity, but it would not be correct to say that you have repressed such activity. Repressing would clearly be present, however, if you refused to admit the existence of the movie or of your desire to see it. In repressing, therefore, you close your eyes to reality.

What we put out of mind or try not to think about is usually the unpleasant. Sometimes we repress by dropping off to sleep. An old gentleman known to the writer always dozed off when he began to read something which seriously assaulted certain ideas to which he firmly held. Charles Darwin was so cognizant of this tendency to avoid or forget the unpleasant, and so intellectually honest, that he made a point of jotting down immediately any observation which failed to support his views. Observations confirming them needed no special attention.

Ego-defensive repression is interestingly demonstrated in an experiment involving failure to solve a series of jigsaw puzzles. College students were divided into two groups, members of each group being given a different "set" concerning the reason for giving them the task to be performed.[11] Members of one group were told that the experimenter wanted to classify the puzzles for further use and that their reactions would assist him. In this group, "interest was mainly centered on the task so that incompletion could mean very little beyond residual tension related to the problem in hand." Members of the other group were given the puzzles as an intelligence test. Thus they might be expected to assume an ego-defensive "set." The investigator says that under these conditions "incompletion would almost inevitably be experienced as failure." Members of both groups were permitted to finish half of the series, but were stopped midway in each of the remaining tasks. Later, each student was asked to name the puzzles attempted.

Earlier research on completed and incompleted tasks had shown that unfinished tasks are recalled more readily than finished

tasks.[12] The hypothesis to be tested by this experiment was that the "intelligence test" group, experiencing personal failure when prevented from completing tasks, would recall fewer unfinished tasks than the other group. The experimental outcome supported this hypothesis. Only eight out of thirty students given the puzzles as an "intelligence test" recalled a preponderance of unfinished tasks. This number is to be compared with nineteen out of thirty for the control group. A comparable outcome has occurred in two more recent experiments,[13] with different materials and somewhat different methods of producing a "threat to self-esteem." *

Attempting to solve serious personal conflicts by repressing may have dire consequences. Many symptoms of neurotic behavior result from repression. Among these are sleep-walking, amnesia (loss of memory — usually for unpleasant realities), multiple personality (coexistence of two or more personalities as in Dr. Jekyll and Mr. Hyde — where one aspect of the total person dominates and the other is repressed), and so-called functional paralyses and anesthesias (loss of ability to control certain muscles and loss of sensitivity, even though the organs concerned are structurally normal). These are all examples of psychoneurotic behavior, discussed more fully in Chapter 24.

REACTIONS TO EXPERIMENTALLY PRODUCED CONFLICT

If a dog is trained to respond to a circle and not to an ellipse, and the ellipse is then gradually made more and more like the circle, a point is eventually reached where the animal does not "know" whether or not to respond. In other words, it is unable to differentiate the two stimuli. When this point is reached, many of the animals suffer a "nervous breakdown." They may whine, struggle when restrained, refuse to eat, and show, in general, what might be characterized as "nervousness." Pavlov, in whose laboratory this type of reaction was first studied experimentally, thought that the breakdown resulted from a conflict between the tendency to make and the tendency not to make a response to the situation.[14] Many later writers have stressed the "conflict" basis of neurotic behavior in human beings.

Behavior disturbances resulting from conflict have since been observed in several animals under a wide variety of experimental conditions. In one study, pigs were subjected to two different environments on alternate days.[15] A 600-cycle tone was sounded one day and a 750-cycle tone on the alternate day. On the day when the 600-cycle tone was presented, cessation of the tone for ten seconds served as a sign that an apple had dropped into the food box. The animal lifted the lid with his snout and got the apple. On the day when the 750-cycle tone was presented, cessation of the tone for ten seconds served as a sign that an electric shock to the foot was about to occur. This training continued for months. Finally, the animal's performance was well stabilized. Whenever the 600-cycle tone stopped, it lifted the lid. Whenever the 750-cycle tone stopped, it lifted its foot and avoided the shock. Then a new condition was introduced. Random lifting of the lid during presentation of the tone on food days and at any time during shock days brought an electric shock. The animal then refused to lift the lid until the apple had dropped. The experimenter, on the other hand, refused to drop the apple until the pig lifted the lid. This was apparently too much for the pig. It showed a marked tendency, first of all, to lift the lid and its foot at the same time, as if "torn apart." Finally, the animal showed "sulky" behavior, went into a sleep-

* One might expect that the group subjected to greater stress would recall more finished than unfinished tasks. This occurred in the experiment described, but later experiments have not confirmed it.

like trance, and manifested many other abnormal reactions.

Rats have also served as subjects in somewhat similar experiments. In one experiment the animals were trained to flex a leg whenever a bright light went on and to refrain from flexing it whenever the light was dim. The difference in brightness was then reduced until it became a difficult problem for the rat to differentiate. Was it to flex its leg or refrain from flexing it? Under these conditions, one rat seemed unable to inhibit leg flexion. It squealed and tried to avoid the experimenter's hand. Another seemed unable to flex its leg.[16] Somewhat similar conditions in a different experiment produced a rigid posture, in which the rat's whiskers were motionless. When removed from the apparatus, the animal maintained positions in which the experimenter placed it. Excessive urination and defecation also occurred in such situations.[17] In a jumping apparatus like that already pictured in Figure 71, difficult or insoluble discrimination problems were presented and the rat was forced, by an electric shock, to jump toward the stimuli. The situation was somewhat comparable with that of the person represented in Figure 152, pressure being applied to force a response under circumstances where there was great resistance to such a response. Sometimes the animals *fixated*, that is to say, persisted in performing, such inadequate responses as jumping always to the right or left, jumping too high, or jumping between instead of at the stimulus cards.[18] In another such study, the force with which the rat jumped from the platform increased as the problem became more difficult.[19] When confronted with situations like these, rats sometimes exhibit behavior disorders culminating in convulsions similar to those of epileptics. One study confronted rats with negative stimuli only, so that jumping was inhibited.[20] The animals were then given an electric shock which forced them to jump. Under these circumstances they became highly excited. One jumped to the floor, ran around with extreme speed, exhibited jerky movements (tics) and had a convulsion.*

CONFLICT, "WILL POWER," AND INITIATION OF ACTION

While they have wide popular usage, the terms *will* and *will power* are seldom used by psychologists, because they really explain nothing. To say that one "wills" to do something, or that he exerts "will power," tells us that he decides or intends to do what he does — that he is not doing it automatically or unthinkingly — but it does not tell us how his decisions are reached or how they are carried over into action. These are the crucial problems. We know much more about the basis of making decisions than we do about the carrying over of decisions into action.

Consider, first of all, the phenomena from which the concept of "will power" is deduced. You are, let us say, confronted by a very difficult decision and, after much deliberation, you assert, "I will do so and so!" Or you are confronted by a very difficult task which will take years to complete. There are many temptations to quit or to put it aside, but you persist until the task has been completed. Or, to take one more of many

* In some such studies an airblast, which has an intense high-pitched sound, was used to force a response. Many animals responded as did the rat mentioned here. But the airblast alone, or any sufficiently intense high-pitched sound from which the rat cannot escape, will also produce such behavior. There is thus doubt as to its basis under airblast stimulation. Some psychologists stress the conflictual aspects of the situation, regarding the behavior as a "neurosis," and others stress the fact that sound alone might reflexly produce such a response. They call the response an "audiogenic seizure." There is evidence that, although sound may itself be sufficient to produce such disorders, they are more likely to occur when a difficult or insoluble problem is also involved. This issue is given a more detailed discussion in the writer's *Handbook of Psychological Research on the Rat*. Boston: Houghton Mifflin, 1950, pp. 421–425.

possible examples, you are listening to an uninteresting lecture, but with great effort keep your attention on what the lecturer is saying. In each of these instances you have, it is claimed, used "will power." Will power is inferred, in other words, when decisions are difficult to make, or when you persist in your endeavors, despite distracting influences. It is never inferred when decisions are easily made or when behavior is lacking in persistence. Nor is it assumed to exist in animals below man. The mother rat may persist in gathering her young, despite the electric grid that she must cross in doing so, but we would not infer that she was using will power. Rather obviously, her behavior persists because the motive to get to her young is stronger than the motive to escape an electric shock.

Psychologists have come to regard the varieties of behavior attributed to "will power" as expressions of the relative strength of motives. If we think in terms of vector psychology the decision stems from the incentives having the strongest positive valence. In other words, those alternatives which, in terms of innate drives and past experience, promise the greatest ultimate satisfaction of motives, determine the direction of choice. To say that "will power" swings the balance is to say no more than that the decision was difficult, but that the motivation to perform one act was stronger than the motivation to perform the other. The Japanese soldier confronted by the imminence of capture had two alternatives. One of these is to save his life by surrendering. But this, in terms of his training from childhood, meant that he would lose self-respect and also the respect of his ancestors and associates. The other alternative was to kill himself. This, in terms of his training from childhood, meant that he would have everlasting glory and honor in the supernatural life that had been promised him. So the soldier killed himself. Because our training does not put life and death in the same light, it seems to us either that such people are "barbaric" or that they have exceptional "will power." Yet, almost anyone, if subjected to the same training, would find the alternative of killing himself much more desirable than that of living a life of disgrace.

A similar interplay of motives is involved whenever behavior persists in the midst of temptations to give it up. If you persist in your efforts to get a college education and put aside temptations to get married and quit, take a job which offers immediate financial rewards, or enjoy yourself at the expense of studying, it is probably because, as you think of the various alternatives, getting a college education exerts more "pull." You may be motivated by the desire to gain prestige, to prepare for further professional training, to please or not disappoint your parents, to finish what you have started, or by a combination of these or other motives.

Some of us find that persistence is made easier if we publicly state what we intend to do. Then, whenever associates ask, "How is that project going?" it acts as a spur to continued effort. By following this procedure, we put ourselves "on the spot." Most of us hesitate to admit that something we have started has to be given up because of our own lack of persistence. If we do give up under such circumstances, we usually find "good" excuses for it — like ill health or interference of other work.

The person who does not persist in his endeavors, who seems to have little "will power," may be one who does not weigh the pros and cons, who does not have any long-range goals, or for whom such goals have only a weak attraction.

Conscience

It is perhaps well to inject here a few words about "conscience," which is supposed to indicate "right" and "wrong," thus aiding us in reaching decisions concerning our conduct. Our conscience is also alleged to

bother us after we have made "wrong" decisions. Actually, there is nothing mysterious about "conscience." In a sense, it is the voice of our parents speaking through us. Take, for example, the following observation.[21]

A three-year-old, awakening full of pep at six A.M., starts tuning up for the day. His weary and irate father from the next bedroom tells him in no uncertain terms to get back into bed, and adds, "Don't you dare get up until seven o'clock."

The boy obeys, but within a few moments mutterings from his room again disturb the father.

Getting out of bed, and going to the door of the boy's room, this is what the father hears:

"Get back in there," says the boy, addressing his leg that is half protruding from the bed.

"Not till seven o'clock," to his arm as he jerks it back from the edge of the bed.

And, as his body squirms half out of bed, he throws himself back vigorously, saying, "You heard what I told you."

From the time of birth there is a more or less constant conflict between what we want to do and what our parents and others around us want us to do. When we suck our fingers, the parent says, "mustn't," "dirty," "only babies do that." There is much "hush, hush" concerning sex. We must forego the pleasure of playing with our sex organs, which are said to be "dirty." We must not ask questions about sex or look at the sex organs of other little boys and girls. We must not scratch. We must not say certain words. There are literally thousands of "must nots" drummed into the child's ear. Whenever he refuses to obey these parental inhibitions, he is punished, perhaps by a harsh word, perhaps by being made to feel ashamed of his babyishness, perhaps by seeing the displeasure of his parents, perhaps by having various pleasures withdrawn, or perhaps by application of a switch or strap. In any case, like the child of the above illustration, he eventually comes to control his own behavior as the parents would control it; often repeating, as if they were his own, the parental words of admonition. The parent said, "You are filthy," and he now says, "I am filthy"; the parent said, "You should be ashamed of yourself," and he now says, "I ought to be ashamed of myself," or "I am ashamed of myself." There is good reason for supposing that language plays an important part in this "interiorization" or "internalization" of parental prohibitions and reproofs. Since these are framed in verbal terms, their acquisition in such terms is to be expected. We know, too, that much of the thinking engaged in by young children is thinking in terms of words, for they "think out loud." Our discussion of thinking showed us that words also play an important role in adult thinking, but on an implicit level.

Initiation of action

Under such conditions as extreme fatigue, alcoholism, low oxygen tension, low blood sugar, hypnosis, and brain injury, we may make decisions, yet be unable to carry them out.

An individual had several drinks and then felt that he should go home. He arrived there all right, but sat down in a chair and read for a while. He then said to himself, "I guess I'll go to bed now." But he did not go to bed. Two hours later he was still sitting and saying to himself, "I guess I'll go to bed now."

Investigators of high altitude flight have found that insufficient oxygen often produces a state like the above. Individuals who wait too long to take oxygen are unable to do so, although they are conscious and know what to do.

An inspector sat in a mine writing a dying letter to his wife while he slowly approached asphyxiation from monoxide gas.[22] His letter did not make sense. It was incoherent and repetitive. But the important point for our purposes is that he knew perfectly well that, by walking twenty yards, he could avoid

death. He had lost the power to initiate appropriate movements.

Related to the problem of "will power," therefore, is the problem of how, once we have chosen a course of action, we initiate the appropriate responses.

Reactions are customarily classified as *voluntary* (literally under the control of will) and *involuntary* (literally not under the control of will). Opening and closing my hand are called voluntary acts because I can control them myself. The contraction of my pupil, however, is involuntary. I have no control over it. It must be aroused by a stimulus which I myself cannot provide by thinking of, imagining, or intending its contraction.

The nervous pathways most directly involved in voluntary activity begin in the motor area of the cerebral cortex and terminate in the striped muscles of the body (see pp. 57, 60). It is therefore apparent that the stimuli which initiate voluntary movement must be applied at the cerebral end of these fibers. It should also be apparent (from our discussion of activities in the association neurons of the cortex) that these activities provide stimulation of the voluntary motor fibers. But what kind of associational activity necessarily precedes voluntary movement? This we do not know in any detail.

Introspective reports indicate that thinking or having an "idea" of a movement precedes voluntary arousal of the movement. We know that thinking of a movement, such as clenching the fist, automatically elicits slight movements of the muscles involved and also action currents which may be measured by means of a galvanometer.[23] The activities of association neurons which underlie thinking of the movement apparently serve to activate the cortical end of the motor pathways. Introspection also reveals that merely thinking of the movement does not produce it — all that occurs is a very slight, or an incipient, movement. If I want actually to clench my fist, I must *intend* to clench it. Here again, although we do not know the details, whatever cortical activities underlie intention apparently stimulate the motor paths which end in the appropriate muscles, and stimulate them in a somewhat different manner from that involved when we merely think of the movement.

We have already pointed out the important role which language, especially in the form of implicitly talking to ourselves, plays in motivational activities. Some investigators believe that language is especially important in the voluntary control of behavior. Their belief is supported by general observations and experiments on the development of voluntary control. Individuals have learned to move their ears.[24] They have learned to move in isolation muscles of the body which are usually not subject to isolated control.[25] They have learned to make the hairs on the body rise "at will."[26] They have learned to contract the small blood vessels in the arm by thinking of a visual pattern or saying a word repeatedly associated (by the conditioned-response technique, Chapter 6) with placing of the hand in icewater and thus, automatic constriction of blood vessels.[27] And they have learned to contract or dilate the pupils by saying or merely thinking the words "contract" or "relax," respectively.[28] Not all the above obviously involved language responses, but they all involved either thinking or language responses. Thinking in man, as we have seen (see pp. 240–241), is partly a subvocal or implicit talking to himself.

The particular stimuli most significantly involved in the control of voluntary movement are those generated by the behavior of the organism itself. The kinesthetic, tactual, and auditory stimuli involved in language are the most important self-induced stimuli in man. By the aid of such receptor processes the organism becomes relatively independent of its external environment and can regulate its own behavior to an extent impossible in infra-human animals. Behavior controlled by the organism's own language responses is voluntary in the highest degree.[29]

SUMMARY

We suffer frustration and the associated psychological stress when our goal-directed activity meets with obstacles which are difficult or impossible to overcome. The obstacles (barriers) are aspects of our physical environment, other people and their attitudes, our own defects, and our inability to resolve conflicting motives. The term conflict is sometimes used to represent distress resulting from frustration. People differ in their ability to retain normal reactions when frustrated. Those who do not "go to pieces," those who can "take it," are said to have a high frustration tolerance. Many people whose frustration tolerance is low lose their goal orientation, doing and saying things which defeat rather than advance their aims. Aggression has been mentioned as one such inadequate reaction to extreme frustration.

When frustrated, the individual should maintain a problem-solving attitude, using all of his resources to reach his goal or to force a resolution of conflicting alternatives. Nevertheless, we are all prone to utilize various compensatory and subterfuge reactions, the prime function of which is not so much to solve our problems as to cushion our ego, our feeling of self-esteem, against threatened deflation. Several such ego-defensive reactions (fantasy, projection, rationalizing, and repressing) have been described.

Fantasy is daydreaming. In its compensatory form, it is imagining that the problems or barriers do not exist, or that we have overcome them. It is ego-defensive and also a means of escape — an implicit running away.

Projection is a reaction to feelings of guilt or feelings of inadequacy. In essence, it is the imputing to others of one's own thoughts and desires. Rationalization is the attempt to justify one's motives or actions by finding "good" reasons for them. Some forms of rationalization, like the "sour-grapes" attitude, although they are not usually considered with compensatory phenomena, are nevertheless compensatory in nature.

Repression is "putting out of mind" or attempting to ignore or forget motives or situations. Extreme repression is sometimes the basis of amnesia, sleep-walking, multiple personality, and functional sensory and motor disorders. The reason for this is that repressed motives often find indirect expression if direct expressions are checked. Inhibition differs from repression in that motives and situations are admitted to exist, and the checking of relevant behavior is carried out with full knowledge of the fact.

Regression is the reversion to childish or less adequate modes of reaction than those called for by the situation. Animals and human subjects show regressive reactions when confronted by frustrating circumstances, especially those arousing intense emotion.

Other reactions discussed in this chapter are identifying (feeling oneself at one with another person or as part of a situation), belittling and blaming others (thus enhancing our own accomplishments by comparison or excusing ourselves because others are at fault), and overcompensating (doing more than is necessary to overcome our defects; perhaps capitalizing on them).

Experiments with animals have demonstrated that extreme conflict, such as occurs when the animal is forced to make difficult discriminations, or forced to respond where previous training inhibits such a response, often produces abnormal reactions simulating those found in neurotic human beings. Extreme excitement, immobility, lethargy, and convulsions have occurred in such situations.

"Will" and "will power" are inferred from reactions to conflict situations, especially

from the making of difficult decisions and persistence of behavior in the presence of obstructions to, or of temptations to give up, endeavors upon which the individual has launched himself. There is no reason to suppose that "will power" corresponds to any force which the individual focuses upon his own behavior. Decisions are made in terms of the relative strength of conflicting motives. When decisions are difficult to make, the pros and cons tend to be closely balanced and the effort involved in making the decision is in weighing the alternatives. Persistence has a similar explanation. The individual who persists in pursuing long-range goals is one for whom these goals, because of his past experience, have a greater attraction than more immediate goals. Conscience comes into this picture because it represents the motive to conform to parental inhibitions or prohibitions. It is, as it were, the parent speaking through the child. Language processes probably play an important role in the internalizing of parental prohibitions. They also play an important part in the initiating of action, once decisions to act have been reached. Subvocal language responses underlie much of our thinking, and the associated activities of the cortex probably provide the impulses which, running from the motor cortex to the muscles, produce voluntary movement.

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Part Six

The Nature and Significance of Emotional Life

EMOTION HAS SUCH VARIED ASPECTS that it defies adequate definition. The term *emotion* is derived from the Latin word *emovere,* which means to stir up, agitate, or excite.

Everybody knows that some emotions, especially when intense, stir, agitate, or excite him. But certain of the milder emotions, like enjoyment of music, parental affection, and admiration, are not especially exciting. We may be "moved," it is true, but neither as much, nor in the same way, as when overcome with anger or fear.

Psychologists sometimes define emotion as a *disturbed* condition. But this definition also fails to cover all emotions. It applies to anger and fear, but hardly to enjoyment, affection, admiration, or others of the so-called "milder" emotions.

Some stress the idea that emotion is *disorganizing* in its effects — that it disrupts rather than facilitates goal-directed activity. But again, some emotional episodes are disrupting and others are not. Even fear may "galvanize" a man to action — and it may be appropriate action. Love may disrupt or disorganize the adolescent's studies, but it may also inspire him to prepare for the day when he can be self-supporting and have a home and family of his own.

The *emergency* value of emotion has often been stressed. Strong emotion frequently energizes. It gives the person reserves of energy which would not otherwise be present — it "lends wings to his feet." But strong emotion sometimes paralyzes action. It makes the person "leaden-footed" or it "roots him to the spot." He becomes "frozen with fear." Indeed many animals are literally paralyzed by sudden threatening stimuli. We speak, here, of "tonic immobility" or of "animal hypnosis." There is no doubt that such reactions often have an emergency value, since movement is quickly sensed by most animals and the motionless prey is relatively safe. But one could claim no such advantage for comparable conditions in man, except when he is in the jungle.

Everything that we have said, and much that we have left unsaid, lends sup-

port to our initial statement that emotion has such varied aspects that it defies adequate definition. A generally accepted definition would have to abstract from the great variety of emotional experiences, overt reactions, and physiological changes something which would apply to all — but not only that. It would need to differentiate emotion from other psychological processes — especially from motivation, which has much in common with emotion.

One psychologist (Elizabeth Duffy) has taken the stand that emotion and motivation cannot be differentiated — that each is a form of "energy mobilization." It is true that hunger, thirst, and other physiological drives involve an element of excitement, especially when frustrated. It is also true that emotions as well as physiological drives activate the organism, causing it to seek out certain situations and to avoid others. But language, tradition, and personal experience all support the idea that hunger and thirst are sufficiently different from, say, fear and anger, to warrant continued use of the terms *emotion* and *motivation.*

Another psychologist (Robert Leeper) stresses the motivational nature of emotion, but rather than looking upon motivation and emotion as identical, he regards the latter as having evolved from the former. According to this viewpoint, the lowest animals possess physiological motives but no emotional processes. A clam, for example, is said to be motivated but without emotion. But "Animals became more complex in their receptor equipment, motor equipment, and capacity for learning. As such complex creatures developed, those that were motivated merely by the long-established physiological motives were not so well equipped for survival. The animal that did not make avoiding responses until it was grabbed by an enemy was less likely to survive than an animal capable of reactions of fear that would be set off by relatively slight stimuli. The animal that had an interest in its offspring — even in the case of the male and in the case of the female even beyond the period of nursing the young — was more likely to reproduce its kind." *

All of this is perhaps true, but we still do not have a generally accepted, or acceptable, definition of emotion. The best that we can do at present is to say that the phenomena discussed in the two following chapters are of the sort generally regarded as emotional.

* Leeper, R. W., "A Motivational Theory of Emotion to Replace 'Emotion as Disorganized Response,'" *Psychol. Rev.*, 1948, 55, p. 19. See also: Duffy, E., "Leeper's 'Motivational Theory of Emotion,'" *ibid.*, pp. 324–328.

14 EMOTIONAL BEHAVIOR

Some Experiential Approaches • Questions for Consideration • Emotional Development: Growth of emotional behavior in children; maturation and learning in emotional development • Situational Aspects of Emotional Development: Fear; anger; smiling and laughter; personal happiness; affection; jealousy; sympathy • Emotional Behavior Patterns: Facial expression; postural reactions; vocal expressions • Physiological Concomitants of Emotion: Investigating physiological changes in emotion; gastrointestinal functions; adrenal discharge in emotion; the galvanic skin response; differentiating emotional from nonemotional states; does each emotion have its own distinct physiological characteristics? • Neural Mechanisms in Emotion: The autonomic nervous system; the hypothalamus; the cerebral cortex • Theories of Emotion: The James-Lange theory; the hypothalamic theory • Summary

ANYBODY WHO HAS OBSERVED his own emotional reactions and those of others already knows a great deal about the most obvious aspects of emotion. What he gathers from direct sources is supplemented by poetry and fiction, as well as by portrayals on stage, screen, radio and television. He knows that there are experiential and physiological as well as overt aspects. He experiences "butterflies" in his stomach, his "heart sinks within him" or is "in his mouth," he feels hot or cold, excited or calm, and so on. What he hears and reads supports his belief that such experiences are aspects of emotion. Indeed it is doubtful whether the reading of books on the psychology of "affective experience" will add much to the knowledge gained through his own emotional experience and what he has gathered from non-scientific literature, especially from poetry, an especially fluent expression of emotional feeling.

Psychologists have made various attempts to subject emotional experience to scientific study, but its subjective nature is an insuperable obstacle. Even if one grants that anything so private as experience can be studied scientifically, he is confronted with the fact that verbal reports of emotional experience (unlike those of visual and auditory experience) differ widely, even from the same individual confronted with the same objective situation at various times. It is well known that when one attends to his emotional experience it tends to weaken and disappear. One cannot "hold" an emotion while he examines it. He can sometimes retrospect and describe what it was like, but even then his description is a poor representation of the "real" thing.

SOME EXPERIENTIAL APPROACHES

In a recent investigation where college students were asked to give introspective reports of emotional experiences, retrospectively, the same situation brought out very different reports and also very meager ones, from the standpoint of what they revealed of emotional experience. About all that the students could do was name the emotion experienced, and it was not the same in all. In one situation which we shall use by way

of example, the subjects were required to crush a snail with their fingers. Here are the verbal reports made by twelve subjects in response to the request for descriptions of experience.

> It was the most horrible part of all for me personally. It is an awful thing to have to do. I didn't like the feel or the sound.
>
> I didn't think it would bother me and when I felt myself making a face, I felt stupid.
>
> It made me sick to my stomach. Had a hard time getting up enough nerve to smash it.
>
> When it popped, it startled me. I disliked it intensely.
>
> It was icky, very distasteful.
>
> I was completely disgusted.
>
> Oh! Ugh! Horrible. I felt complete and utter repulsion. (She probably meant "revulsion.")
>
> It was the most distasteful situation of all. I didn't want to do it.
>
> I don't like to touch things that are so slimy and gooey and break so easily. I didn't know they broke so easily. It was awful.
>
> It was very distasteful, acutely unpleasant.
>
> It was repulsive. You probably couldn't get everyone to do that.
>
> The situation didn't bother me at all.[1]

Studies of emotional experience in which subjects check off such items as pleasant, unpleasant, excitement, calm, and the like, reveal little beyond what one already knows. They demonstrate that most people experience fear as unpleasant and exciting and as involving tension and strain; joy as pleasant, bright and warm; and sorrow as unpleasant, depressing, and dull.[2]

What can the lover be expected to reveal of his experience that is more eloquent than "Parting is such sweet sorrow"? Yet even this tells us little of Romeo's experience beyond naming it.

Even agreement that a certain episode is "disgusting" or "depressing" is not necessarily proof that the same emotional "feeling" is experienced by different people and the association of such words as "brightness" and "warmth" with "joy" may be more of a linguistic custom than anything else. The reader may recall from our previous discussion (p. 20) that the scientific treatment of experience is beset with such difficulties.

The physiological aspects of emotion, except as revealed in experience, are not such common knowledge as feelings. But they clearly lend themselves to scientific investigation. Psychologists as well as physiologists are interested in the physiological concomitants of emotion largely because they hope that a knowledge of glandular and neural processes will show how emotional experience and behavior are generated. As we shall observe later, one theory regards emotional experience as the "feeling of bodily changes" whereas another assumes that emotional feeling and emotional behavior are both activated by discharges from the hypothalamus.

QUESTIONS FOR CONSIDERATION

The chief questions to be answered by research on emotional behavior concern the development and characteristics of behavior patterns like those observed in fear, rage, love, sympathy, and so on. In the remainder of this chapter we shall focus upon such questions as: What emotional behavior is evident at birth? How does the emotional repertoire change as a child grows older? What features of emotional development are attributable to maturation and what to conditioning? How are emotional reactions to particular objects or situations, like snakes and darkness, acquired? To what degree do emotions have different postural and facial expressions? What are the physiological and neural bases of emotion? What are the chief theories and how do they relate the experiential, physiological, neural, and overt manifestations of emotion?

EMOTIONAL DEVELOPMENT

An early investigation of emotional behavior in infants suggested that three emotions are present at birth; namely, *fear, rage,* and *love.*[3] More recent investigations, however, have failed to verify this suggestion. They have shown that

> any form of sudden stimulation such as dropping, loud noises, restraint, pain, or a rush of air on the face, produces in the young infant aimless activity of most of the musculature, accompanied by crying. The stimuli must be sufficiently strong, however, to produce a reaction. When an infant below four or five days of age is dropped one or two feet, it frequently shows no perceptible response, except for vague movements of the arms and legs. The younger the infant the stronger must be the stimulus. This is also true for so-called "pleasurable" stimuli, such as stroking or petting, to which many newborn infants show no reaction.[4]

One investigator found only "mass activity."[5] Another found that any of four stimulating conditions produced "any and all responses."[6] Still another found only "excitement."[7]

The original investigators were apparently labeling the behavior fear, rage, and love in terms of how they would react if stimulated as the babies were stimulated. In other words, knowing that sudden loss of support would produce fear in themselves, they designated as fear the behavior elicited by loss of support. Moreover, they failed to observe or take into consideration such differences in reaction as were apparent to later observers.

Psychologists must always be on guard against "reading into" behavior something that is not there. In an experiment to determine how much graduate students in psychology, nurses, and medical students agree concerning emotional reactions of newborn infants, it was found that significant agreement was present only when the stimulating circumstances were known to the observers, and they were thus able to "read" their own reactions into the situation.

The emotional reactions elicited by hunger, dropping, a loud noise, pin-prick, and several other stimuli were presented in some instances on a motion-picture screen and in other instances directly, by having the judges look at the baby after a screen had been removed. In the first series of observations, stimulating circumstances were not known to the observers. Here there was little or no agreement concerning the emotion exhibited. For example, forty-two medical students who observed the reactions to dropping directly, but without knowing that the baby had been dropped, gave the following designations to the behavior: hunger (6), pain (3), fear (2), anger (7), colic (11), awakened from sleep (11), bandage tight (1), and organic brain emotion (1). Thirty-two graduate students in psychology who saw films of reactions aroused by dropping, but did not know that dropping had occurred, gave the following designations: hunger (6), anger (14), fear (5), pain (3), grief (1), rage (1), consternation (1), and nausea (1). There was similar lack of agreement concerning behavior aroused by other stimuli. It is apparent that an individual is not likely to label the behavior as others label it when he does not know the stimulus which caused it. When the same graduate and medical students saw the stimulus as well as the behavior, they showed much closer agreement than when they witnessed the behavior alone. For example, 27 out of 41 said that dropping produced fear and 24 out of 39 that restraint produced rage.[8]

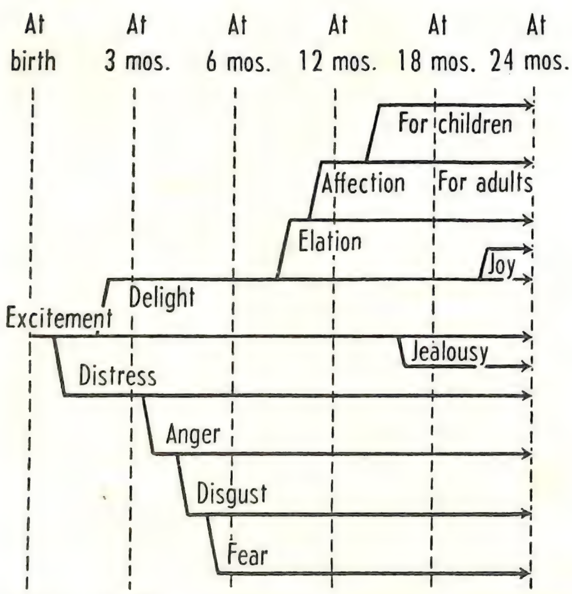
It is apparent, therefore, that the emotional behavior of the newborn fails to show clear-cut patterns to which definite emotional labels such as fear, rage, and love can be attached.

Growth of emotional behavior in children

Although the newborn child shows only

general excitement when stimulated by situations which arouse emotion in older children and adults, other emotional reactions are soon apparent. Psychologists do not agree on the labels to be attached to manifestations of emotion at particular age levels, but they agree that, as the child grows older, an increasing number of emotions becomes apparent.

The diagram shown in Figure 155 illustrates one of the several classifications of emotional behavior in early childhood. It is based upon observations of a large number of babies in a foundling home, who ranged in age from newborn to two years.[9] In newborn infants, the investigator could discern only general excitement. But in the three-month-old child distress and delight, as well as general excitement, could be distinguished. Within the next three months, distress was differentiated so that fear, disgust, and anger were also apparent. At about twelve months, delight had differentiated so that elation and affection were added to the repertoire of emotions. Jealousy and affection for children, distinguished from affection for adults, appeared between the twelfth and eighteenth months. Between the eighteenth and twenty-fourth months, delight was differentiated so that joy was also evident.



155 **Approximate Ages of Differentiation of Emotions in Early Childhood**

(Adapted by Dashiell from Bridges, K. M. B., "Emotional Development in Early Infancy." Child Development, *1932, 3, p. 340.)*

One should not, of course, accept as gospel the particular labels and age levels indicated in the diagram. We should look upon it rather as one psychologist's attempt to represent emotional development in children. The above discussion of early investigations of infant emotion should warn us that even an experienced psychologist may "read into" the behavior of infants more than is actually present, and that different observers may assign different labels to the same reactions. The classification is presented here merely to illustrate the fact that one who perceives only general excitement in the newborn discerns an increasing variety of emotions as the child grows.

The possibility of differentiating emotions at advancing age levels is further illustrated in Figure 156. Nobody would judge A to be happy, but is he hurt, angry or afraid? Without a knowledge of the cause, one cannot say. The two-year-old in B exhibits a clearer pattern of emotion. Anger, resentment, or disappointment appears to be present.[10]

Maturation and learning in emotional development

Both maturation and learning play important roles in emotional development. In some instances it is possible to recognize their respective influences, but in others they are inextricably related.

Maturation. The influence of maturation is clearly shown when, without any opportunities to acquire them, the infant exhibits such emotional responses as crying, weeping (crying with tears), smiling, and laugh-

A

B

156

Differentiation of Emotion at Different Age Levels

One might have difficulty in judging the emotion expressed by the baby at the left, but the older child almost certainly is expressing anger, resentment, or disappointment. (Photos by Roy Goin and Doris E. Wright. After Goodenough, F. L., Developmental Psychology *(2nd Ed.), New York: Appleton-Century-Crofts, 1945, p. 199.)*

ing. These emotional reactions appear at about the same age in all children, regardless of variations in stimulation provided by adults. They also occur where all opportunities to witness them in others have been removed.[11]

Further evidence that maturation plays a large role in emotional development comes from observations of individuals born blind and deaf. Such persons (see Figure 157) would have very little, if any, opportunity to acquire emotional behavior by imitating others. They certainly could not hear the sound of laughter and observe how it is produced, they could not see individuals clench their fists in rage, and they could not see the various facial expressions of emotion. The only way in which such expressions could be known to them would have been through touch. But even when they have been given no tactual training, they exhibit emotional reactions which have much in common with those of normal people. Take, for example, the following observations of emotional behavior in a ten-year-old girl who was blind and deaf from birth, who had not been able to learn to speak or to care for herself, and who had received no training in emotional expression.

A small doll was dropped down the child's dress, whereupon neck and shoulders tensed and the mouth half-opened. The sightless eyes opened to the fullest extent and the eyebrows were raised. The left hand at once began to grope for the toy. Both the posture and the facial expression were suggestive of what we should ordinarily interpret as startled attention. After several minutes of unsuccessful efforts to get the doll, which caught in the folds of her dress, she did not cry, but made slight whimpering sounds. . . . Suddenly, as if struck by a new idea, she renewed the attack, this time from a different angle. Her behavior took on the appearance of a struggle, determined in part by exasperation and mild rage. Her body writhed and twisted; the right hand impatiently beat the arm of the chair. . . . At the instant of success in extricating the doll, she threw herself back into the chair with feet drawn up under her.

157 **Emotion in Blind-Deaf Children**

These children, like the child discussed in the text, were born blind and deaf. (Photo courtesy of Perkins Institution for the Blind.)

Both the hand containing the doll and the empty hand were raised in an attitude of delight, which was further attested by peals of laughter. . . . The exultant laughter faded to a smile of pleased satisfaction.[12]

Learning. The role of learning in emotional development is clearly evident when we consider the stereotyped gestural and facial expressions which are not common to all men, but which characterize a particular culture. An interesting comparison is provided by our own and Chinese expressions of the same emotions, or what are presumed to be the same emotions. Some emotional expressions are similar in us and in the Chinese, but others are very different. Surprise in us is made evident by raising the eyebrows and opening the eyes wide, but the Chinese usually express surprise by sticking out their tongues. Scratching ears and cheeks is a sign of embarrassment in us, but to the Chinese it means happiness. Clapping the hands is a sign of happiness in us, but of worry or disappointment in the Chinese.[13] These emotional expressions are superimposed upon inborn expressions like those of the deaf-blind child. They are acquired from observing similar expressions in others.

The role of learning is also evident when we consider how particular emotions are aroused by different objects and situations as we get older. Thus, infants, like the infant of Figure 158, are usually not afraid of snakes. Fear of snakes usually begins to develop at about two or three years of age.[14] Maturation, in the sense of giving the older child a keener perception of the peculiarity of the snake's movements, may be involved. But fear of snakes as particular objects comes from hearing stories about snakes, observing how older children and adults react to snakes, and perhaps by transfer to snakes of a fear of the strange or the unusual, acquired in other circumstances. Some older children and adults never develop a fear of snakes.

Studies of children's fears and those of their parents have shown that there is a close relation between the two.[15] In other words, if the parent is afraid of the dark, of lightning, of snakes, or of particular individuals, the child will very likely have the same fears.

A classical experimental study of the acquisition of fear in a child is the case of Albert.

Albert, a normal child of nine months, exhibited fear reactions to a loud noise unexpectedly presented, but had no fear of white rats. Fear of rats was acquired under the following circumstances: When the rat was first placed before him, Albert reached for it, showing no signs of fear. Just then a loud noise was made behind his head by striking an iron bar. Albert started and fell forward on his face. . . . The rat and noise were again presented, the noise just after the rat. This time Albert responded as before except that a whimper was added. After five further

A

B

158

Evidence That Fear of Snakes Is an Acquired Fear

Annette Avers has had snakes as pets since her sixth month. In picture A she is shown at the age of fourteen months. At seventeen years (B) *she is still fond of snakes, and keeps them as pets. (Courtesy of Mr. Franklin H. Avers.)*

presentations of the rat and noise, separated from the other two trials by a week, Albert was afraid of the rat alone. Not only this, but he was now afraid of objects closely resembling the rat in certain respects. For example, the same fear reaction was aroused by a rabbit, a dog, a sealskin coat, and a mass of absorbent cotton. Wooden blocks and other objects bearing no similarity to the rat did not produce the response. The fear reaction to rat, rabbit, dog, coat, and cotton was evident a month later, but it had decreased in intensity.[16]

It is evident that, by associating some stimulus which produces emotion with a stimulus which does not produce it, we may give emotion-provoking potency to the previously neutral stimulus and to stimuli similar to it. The technique here is, of course, that of conditioning.

When a newborn infant is emotionally aroused, about all he can do is cry and thrash his limbs about. As he grows older, however, his emotional behavior shows a much wider range, some of it attributable to maturation and some to learning. Thus, the emotionally aroused one-year-old can stiffen his body, hold out his arms, throw things, call out, and cling to an object or person, as well as cry and thrash his limbs. As he gets older, language responses play an increasing role in his emotional behavior. He makes demands, scolds, pleads, swears, talks about others, and makes his feelings felt in many other ways.[17] Most of these acquisitions are not emotional in themselves. They are

merely utilized in emotional situations as well as non-emotional ones.

Other acquisitions give the child a greater control over his environment, thus reducing frustration and other emotion-provoking situations. He learns to help himself by getting out of bed alone, to satisfy his hunger by going to the pantry shelf, and to protect himself by fighting the neighborhood bully.

SITUATIONAL ASPECTS OF EMOTIONAL DEVELOPMENT

At birth, relatively few situations arouse emotional behavior, or what we infer to be excitement. Such stimuli as a loud noise, a sudden loss of support, and stroking of the erogenous zones are often emotion-provoking to the newborn, but they do not, as we have seen, arouse differentiable reaction patterns. Marked restriction of activity, as by holding the head between the hands, is also prone to arouse excited behavior. Emotional reactions are frequently elicited by hunger, colic, having the nose cleaned, and other bodily discomforts. Crying is the most specific response to such discomforts, but it is usually accompanied by thrashing about of legs and arms. Any abrupt change in the situation, such as the turning on of a light, a sudden noise, or the appearance of a person, will usually produce a startle reaction.

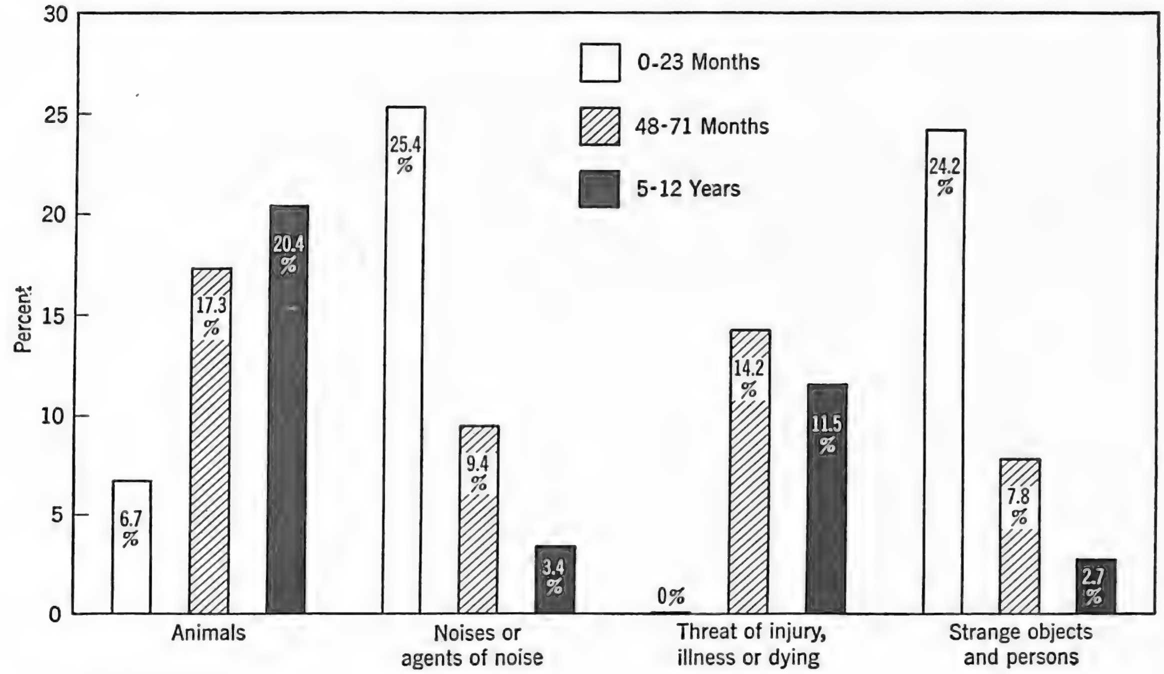
During early development, maturation and learning give potency to many stimuli which failed to elicit emotional reactions at birth. Following the conditioning principles already discussed, fears of particular objects, persons and situations are likely to develop. Grotesque masks do not frighten an infant in its first months, but they do an older infant, until he becomes accustomed to them. Scolding and frowning at a baby of three months is likely to elicit laughter, if anything at all, but frowning at or scolding a child of six or seven months is more than likely to arouse behavior suggesting anxiety or astonishment.[18]

Fear

In one investigation of the situations which arouse fear in children of various age levels, observations by parents were supplemented by interviews with children. The parents were especially trained to make and record their observations. An idea of the nature of the findings from this study may be gathered from Figure 159, even though only four of the ten classifications of fear-provoking situations are included. It is quite apparent that animals increase and that noises and strange things decrease in emotional significance as the child grows older. Threats to life and limb, on the other hand, are completely ineffective as instigators of fear during the first two years. They increase, then decrease in potency as the child grows older.[19] At the higher school ages, new fear-provoking situations arise. Fears (and worries) concern such things as school work, loss of prestige, aspects of sexual maturity, and financial difficulties. A group of college girls who kept a diary of emotions for one week and then reported their findings anonymously were found to have their fears centered primarily around school work (40 per cent of all instances of fear), anticipated loss of prestige (30 per cent), and illness and physical danger (17 per cent).[20]

Anger

Anger in children is most frequently aroused by frustrating situations, like having to stop playing, having something taken away, or being pushed around by another child. Even in college students, thwarting is the most common situational factor in anger. The group of college girls mentioned above were angered most frequently by interference with their plans (52 per cent of all instances). Even inferiority and loss of prestige (21 per cent) and school work (13 per cent) could be considered as anger producing because of their frustrating effects.[21] In



159

Per Cent of Each Group Fearful in Four Emotion-Producing Situations

(Drawn from data in Jersild, A. T., F. V. Markey, and C. L. Jersild, "Children's Fears, Dreams, Wishes, Daydreams, Dislikes, Pleasant and Unpleasant Memories." Child Development Monograph, *1933, No. 12.)*

another study, involving college men and women, thwarting of self-assertion accounted for most of the anger outbursts which occurred in one week. Persons were the chief anger-arousing agents.[22]

Smiling and laughter

Smiling in response to a smile does not usually occur before the child is about two months old. Laughter usually appears about one month later.[23] Such situations as peek-a-boo games, tickling, and word play are common laugh-provokers in young children. Later there is ability to appreciate things that older persons might regard as humorous — like seeing someone fall, become the victim of a practical joke, or act in an incongruous manner. Appreciation of cartoons, verbal jokes, and the humorous aspects of such stories as *Penrod* and *Tom Sawyer* develop during the early school years.

The essential conditions for laughter, or humor, have intrigued philosophers for centuries. There are various theories as to what constitutes the humorous, none of which seems likely to receive general acceptance, but all of which perhaps have an element of truth. Some of these alleged causes of humor are: "An error or deformity which is not painful or destructive" (Aristotle), "a strained expression suddenly being reduced to nothing" (Kant), "an expression of incongruity" (Schopenhauer), a feeling of "sudden glory" (Hobbes). After considering these and other theories concerning the situational aspects of humor, one writer comes to the conclusion that the essential elements are "the sudden perception of a contrast between things as they are, and things as they

ought to be or are thought to be or are expected to be." [24]

Personal happiness

Happiness in childhood is associated primarily with such things as playing and being read to. Later it is also associated with reading, hobbies, and engaging in various social activities, including games. A continually happy or unhappy child is rarely observed. It is also unusual to observe a continually happy or unhappy adult. In a study of happiness in college students, 33 of a group of 112 students reported that they were almost always happy and only three said that they were almost always unhappy. Forty-eight were more often happy than unhappy. Of particular interest to us here, however, are the situational bases of happiness. The bases of happiness which rated highest were, in order of frequency, good health, joy of work, love, and a clear conscience.[25] In another study, graduate students in education rated joy in work as the major factor in happiness.[26] In still another study, students rated by themselves and associates as above average in happiness were also rated above average in competence and efficiency.[27]

Affection

The most primitive basis of affection is doubtless pleasure associated with stimulation of the erogenous zones, warmth of the mother's body, suckling at the breast, and being fondled and cuddled.*

The stimuli for affection in older infants are many. The writer's boy had a toy rabbit, soft and woolly, which he took to bed with him for years and hugged and kissed like a person, even when it grew decrepit beyond description. This sort of thing happens in almost every family. The basis of such affection for objects and persons is not very readily traced. There is reason to suppose, however, that the unconditioned stimuli are such as the mother provides and that other objects and persons become conditioned (substitute) stimuli for affection. As the child grows older, however, the stimuli which will arouse affection are limited by cultural influences like those mentioned in our discussion (pp. 285–288) of social and cultural factors in motivation. Sexual attraction of course becomes a potent factor when members of the opposite sex, and sometimes of the same sex, are concerned. Sexual factors probably play a minor role in maternal and paternal affection and in normal affection for members of the same sex.

Jealousy

Jealousy, as indicated in Figure 155, is a late-appearing emotion. It can occur only in social situations, hence it does not appear until a certain degree of social perception and participation has developed. The most frequent cause of jealousy in young children is the arrival of a new child in the household. The mother's attention to the newcomer, especially when it detracts from that formerly enjoyed by the older child, often arouses such reactions as that pictured in Figure 160. Quite frequently the younger child is attacked, sometimes seriously injured. Jealousy may also be expressed by ignoring the other child, denying that he exists, refusing to eat, and bed-wetting. This emotion also occurs in many other situations where a threat to accustomed pleasures or to prestige is involved. Playmates become jealous when a friend forms new attachments. Quite often, too, the child becomes jealous of the attention paid by one parent

* Babies denied such stimulation during early development are often markedly retarded in bodily growth. A doctor who has studied the development of hundreds of babies in hospitals and other institutions reports that stimulation such as children normally get from the mother, even from rocking and the like, is necessary for normal physical as well as emotional development. See Ribble, M. A., *The Rights of Infants.* New York: Columbia University Press, 1943.

160

One Expression of Jealousy

In this case jealousy is expressed by sulking. Often, however, the older child will give expression to her jealousy by attacks upon the younger one. (Photo by Vivien Rodvogin. Courtesy of Parents' Magazine.)

to the other. There is little doubt that sex is involved in the jealousy of older children, adolescents, and adults. Ways of expressing jealousy change with age, although sulking and direct or verbal attack are rather persistent at all age levels.

Sympathy

The most common stimulus for sympathy is seeing, hearing, or learning of someone else in distress. Identification (p. 311) is involved. This is "feeling oneself into" the other person. Why we feel sympathy for others has received considerable discussion. Some have regarded it as an essential aspect of gregariousness (p. 286) and as inborn. Thus McDougall, who thought of sympathy as an instinct rather than as an emotion, said that

sympathetic induction of emotion and feeling may be observed in children at an age at which they cannot be credited with understanding of the significance of the expressions that provoke their reactions. Perhaps the expression to which they respond earliest is the sound of the wailing of other children. A little later the sight of a smiling face, the expression of pleasure, provokes a smile. Later still fear, curiosity, and, I think, anger are communicated readily in this direct fashion from one child to another. Laughter is notoriously infectious all through life, and this, though not a truly instinctive expression, affords the most familiar example of sympathetic induction of an affective state. This immediate and unrestrained responsiveness to the emotional expressions of others is one of the great charms of childhood.[28]

This statement implies that there is a more or less automatic response, as well as considerable ability to respond differentially,

to variations in another's emotional expressions. Some aspects of this problem are considered in the next chapter, where judgment of facial expression is discussed (pp. 365–370). It should be noted here, however, that the person in whom sympathetic response is aroused may be responding to the emotion-provoking situation rather than, or in addition to, the emotional expressions of another. A conditioned response theory of sympathy supposes, therefore, that one's sympathy is based upon how *he* has responded (or felt) in comparable situations. According to this theory, "the emotion aroused in the sympathizer is a part of his own system of emotional habits from past experience, evoked as a conditioned response to some element common to the original and the present situations." [29] This is to say that a child who cries or feels sad when he sees another child in trouble is exhibiting the response which he has himself previously manifested in comparable situations. This is a plausible explanation of many instances of sympathetic behavior, but it needs much amplification if it is to account for all of them. It seems but a first step. Take, for example, the following account of sympathetic behavior in preschool children. Only the first part — "sympathetic imitation" would be covered by either of the above theories.

> Some children seem to be much more sympathetic than others — that is, they are moved or affected by another's distress. As a rule children make no attempt to express such sympathy at first, they only stare or perhaps cry in sympathetic imitation. Later, when they are more socially adjusted, they express their feelings by trying to comfort the child in trouble. This may take the form of an affectionate embrace or an arm put gently around the distressed child. It may take the form of comforting words as "Don't cry, I'll ask my Mummy to get one for you," or it may take the form of simply asking "What are you crying for?" or "Does it hurt?" in gentle, kindly tones.[30]

There seems little doubt but that, whatever the basis of sympathy, as an emotion, the sympathetic responses described above, and they are perhaps typical, are acquired from the social milieu. The child does what his parents and others have done for him and what he has observed people do for others in times of distress.

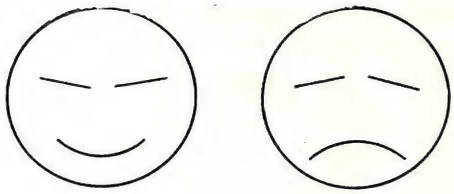
EMOTIONAL BEHAVIOR PATTERNS

In discussing the development of emotional behavior and the varying potency of emotion-provoking situations at different age levels, we have carefully avoided the implication that each emotion has a set, stereotyped behavior pattern. The reason for hesitating to give stereotyped descriptions is that variations in emotion, even within a particular culture, are often more obvious than uniform expressions. Even under the same external circumstances, emotional behavior differs considerably from one person to another. Sometimes different emotions are experienced by the different persons, depending upon how they perceive or interpret the situation. But even when verbal reports name the identical emotion, the behavioral reactions often differ a great deal. One person grits his teeth, another cries out, and still another inhibits all overt expression.

Despite such variation in emotional behavior, there are a few things that can be said about certain similarities amid the evident diversity of expressions. Psychologists have searched for these similarities, giving special attention to facial and postural aspects.

Facial expression

If we divide facial expressions of emotion into two groups, depending upon whether their experiential aspects are markedly pleasant or unpleasant, we find one differentiating feature which is so uniform that hardly anybody can fail to observe it. This

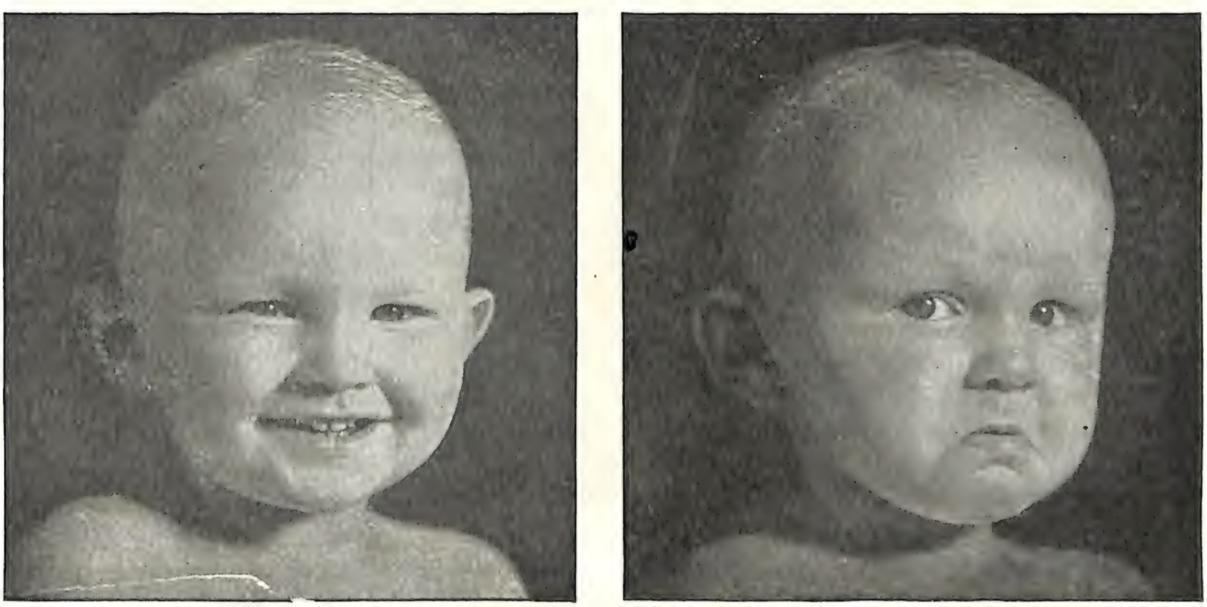


161 **Two Opposite Emotions as Suggested by Leonardo da Vinci (1452–1519)**

is the position of the mouth. Leonardo da Vinci represented this difference in drawings like those of Figure 161. One has no difficulty in perceiving which figure represents the pleasant and which the unpleasant emotion. Nor can one fail to discern which of the faces in Figure 162 represents the pleasant and which the unpleasant emotion. On the left is the child's expression when pleased, but that on the right was elicited by telling him that he could not have a desired article. The lines of the mouth agree very well with Leonardo's sketches. The eyes, pictured by Leonardo as slanting in the same direction as the mouth, are not as clearly differentiated as the mouth.

It is much easier to differentiate expressions of pleasant and unpleasant emotions than it is to differentiate expressions of specific emotions, say, joy versus love or sorrow versus fear.

Most of the research on facial expressions of emotion has dealt with ability of individuals to judge what specific emotions are being expressed, not with the more fundamental problem of what expressions (inborn or acquired, or both) characterize the various emotions. The problem of judging emotions in the laboratory and under conditions of everyday life, as well as on the stage or screen, is dealt with more fully in the next chapter. It is obvious, however, that when people of a given culture almost universally judge an expression to be a certain emotion, they are differentiating that expression



162 **Two Facial Expressions of Emotion**

Pleasure and displeasure are clearly discernible here. Compare with the diagrams suggested by Leonardo. (Courtesy R. H. Ross.)

from expressions of other emotions. If they can do this, moreover, the different emotions must have distinctive expressions. We shall anticipate later discussions by saying that some facial expressions, especially those for laughter, surprise, horror, and grief, are judged with a high degree of uniformity. Few judges confuse them with each other or with expressions of still different emotions. The facial expressions of these emotions must, then, have certain distinguishing characteristics. But we must not infer that the distinguishable emotional expressions are inborn. Uniformity of judgments may mean merely that most people acquire, and learn to distinguish, the stereotyped emotional expressions of their culture. Actually, as we saw in our discussion of emotional expressions in the congenitally blind and deaf, there are certain inborn expressions upon which the cultural and individual expressions are superimposed.

The chief difficulty with attempts to discern the inborn, universal expressions of emotion is that of disentangling these from acquired expressions. Studies of facial expressions in the congenitally blind, and blind and deaf, demonstrate that both innate and acquired aspects do exist, but they have not, as yet, yielded a clear characterization of either.

One drawback in all research in this field

163

Variety of Emotional Expression in One Situation

Emotional reactions and expressions vary widely, even among individuals of a fairly homogeneous group. Here the camera catches the facial expressions and gestures of a group of Hunter College students watching a baseball game between the faculty and the male student body. (Photo by Hamberger, from Black Star.)

is that only a few emotions can be aroused under laboratory conditions, where techniques for analyzing them are alone available. These are emotions like fear, anger, disgust, and humor. Even the fact that these are aroused in the laboratory, rather than under more natural conditions, perhaps makes their expression less spontaneous than one would desire. In one recent study, for example, subjects said that they laughed at a joke not because they thought it funny but because they knew that the experimenter expected them to laugh.

Granting that "real" emotions are at times aroused in the laboratory by such stimuli as snakes, electric shocks, crushing snails, looking at lewd pictures, and revolver shots, what uniformities in facial expression do these studies reveal? Still and motion pictures have been taken and the facial expressions analyzed, muscle by muscle, in an effort to find whether a particular situation, or emotion, as reported by the subject, elicits a uniform pattern. The upshot of one such study was the conclusion that neither a given situation nor a given emotional experience brings out a uniform pattern of facial expression.[31] (As an example of one situation eliciting a great variety of facial expressions of emotion examine Figure 163.) A later, somewhat different statistical analysis of the same data led another investigator to conclude that while different situations and experiences aroused certain more or less common expressions, some expressions were more prevalent in certain situations and emotions than in others.[32] Smiling, for example, occurred in only 7 per cent of the instances of reported pain, but in 60 per cent of the instances of sexual emotion; the nasalis muscles were involved in 52 per cent of the instances of reported pain, but in only 4 per cent of the instances of crying; and so on. But this is still far from providing a clear picture of specific expressions for particular emotions.

A somewhat more promising lead, as yet applied only to startle, is the utilization of extremely rapid motion picture photography.[33] If an emotion has an inborn pattern of expression, upon which cultural and individual features are superimposed, the inborn pattern may be so rapidly followed by the latter that they mask it. In the case

164 **The Startle Pattern**

This expression, which is remarkably uniform from one person to another, has been photographed with cameras running from 64 to 2200 exposures per second. The stimulus was a revolver shot. "The first and most notable feature of the facial pattern is the immediate closing of the eyes. Then there is a widening of the mouth as though in a grin, although this only occasionally leads to a real baring of the teeth. The head and neck are brought forward. Sometimes, as the head comes forward and down, the chin is tilted up so that the features are still directed straight ahead despite the movement. The muscles in the neck stand out, with the sternomastoid most prominent and the trapezius and platysma also noticeable. In very strong reactions other minor muscle groups in the neck and face seem to be involved. It is even possible in rare instances, to notice a twitching movement in the scalp and ears." Although certain aspects of this pattern may be absent on some occasions, the eye-blink is always present. (Redrawn from Landis, C., and W. A. Hunt, The Startle Pattern. *New York: Rinehart, 1939, p. 23.)*

of startle, which is more a reflex than an emotion, rapid photography (up to 2200 frames per second) has "frozen" the initial expression and demonstrated that it is highly uniform from one person to another. Very rapidly superimposed upon this expression, pictured in Figure 164, are others which differ greatly among individuals.

Without ultra-rapid motion picture photography, one would have been led to believe that there is no clear uniformity in the startle response. Application of this technique to the various emotions might well disclose much more uniformity of facial expression than is at present evident. The difficulty would be in arousing natural expressions within the range of the camera.

Postural reactions

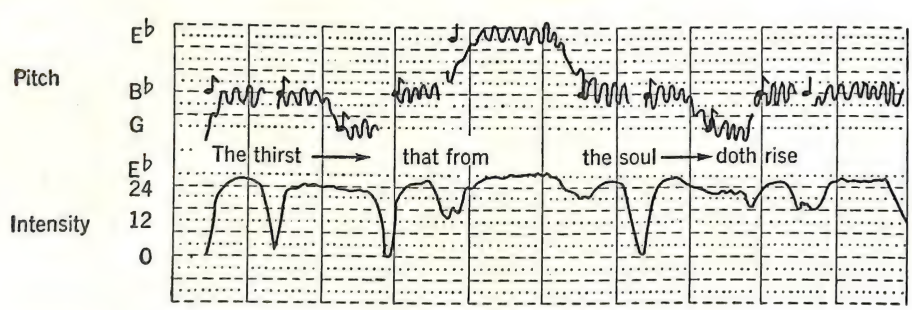
Certain emotions tend to arouse different general postures, although there are great differences in reaction from one individual to another, as in the case of facial expression. Fear often involves either flight or being "rooted to the spot." Violent anger often involves, not flight, but aggressive movements, either abusive or involving actual attack. Love usually involves movement in the direction of the loved one and, where tactual stimulation is involved, movements conducive to continuation of the stimulus. Sorrow is often associated with a general slumping posture, whereas joy often involves the opposite posture, with the head held high and the chest out. Movements of the hands, as in clenching of the fists and gesticulating are often quite expressive emotionally. How much of these expressions is natural and how much culturally conditioned is a question for research.

Such postural reactions as we have mentioned are given especial emphasis in the James-Lange theory of emotion which we will discuss shortly. According to this theory, stimulation produced by assumption of postures contributes to the feeling aspect of emotion.

Vocal expressions

The voice is emotionally expressive, as testified by screams, groans, sobs, laughter, and the like. Language also expresses emotion. Readers acquainted with the recording "I Can Hear it Now" * will recall how Arthur Godfrey's voice breaks in describing the funeral of President Roosevelt and how Herbert Morrison breaks down emotionally in describing the Hindenburg disaster as it occurs before his eyes. Singers often inject

* Columbia.



165 **A Strobophotographic Record of Emotion Expressed in Singing**

Periodic variations in pitch, as shown in the upper part of this record, are known as vibrato. *Vibrato is an aspect of vocally expressed emotion. (Courtesy of Harold Seashore.)*

much emotional expression into their singing. Observe, for example, the record illustrated in Figure 165. Here is a graphic picture of how Lawrence Tibbett, in singing the fifth phrase from "Drink to me only with thine eyes," injects the emotional element. Note, especially, the periodic variations in loudness and pitch (vibrato) and how long "from" is held, as compared with "the." "Fast tempo, high register, and major mode tend to suggest joy, and their opposite to suggest sorrow. Staccato notes indicate gaiety or agitation." However, college students, when asked to characterize unfamiliar musical selections in terms of the emotion intended by the composers, often fail to agree with the composers. To use a slang expression, "they fail to get it." [34]

PHYSIOLOGICAL CONCOMITANTS OF EMOTION

Some physiological concomitants of emotion are evident in everyday experience. Palpitation of the heart, accelerated breathing, weakness, sinking feeling in the stomach, sweating, trembling, and many other such phenomena are commonly reported aspects of emotion. During World War II, thousands of soldiers were questioned concerning the felt symptoms of fear. Some of the symptoms most frequently reported by them are summarized in Table 6. The frequency of each particular symptom is in terms of the percentage of soldiers reporting it.

TABLE 6. SOME FELT SYMPTOMS OF FEAR *

	%
Violent pounding of the heart	86
Sinking feeling in the stomach	75
Feeling sick in the stomach	59
Trembling and shaking	56
Cold sweat	55
Tense feeling in stomach	53
Feeling of weakness and faintness	51
Vomiting	24

* Quoted from p. 384 of *Psychology for the Armed Services* (E. G. Boring, Ed.), by permission of the Infantry Journal Press, publisher.

Much of the research on emotion has been focussed upon such physiological concomitants as respiration, blood pressure, pulse rate, limb volume, sweat-gland activity, gastrointestinal functions, metabolic rate, and chemical changes in the blood. This research may be said to have two aims: to discover (1) how various physiological processes change during emotion, and (2) whether there are different patterns of physiological change underlying specified emotions, such as fear, rage, and disgust.

Investigating physiological changes in emotion

Most studies of the physiological concomitants of emotion record several physiological changes simultaneously. A typical setup in research and laboratory demonstrations is shown in Figure 166. Here we have devices for measuring respiratory and circulatory changes. Another record of such changes is illustrated in Figure 167.

Activity of the heart in emotion is often studied by examining the shape of the curve obtained with an electrocardiograph. This instrument makes records of the electrical activity of all aspects of the heartbeat. In research on emotion, the analysis of electrocardiograms indicates changes in heart action and the duration of such changes.

Gastrointestinal functions

These functions are often measured by means of balloons inserted into stomach or intestines. The reader will recall our discussion of the use of such balloons in the study of stomach contractions related to hunger. Gastric functions in emotion have also been studied by fluoroscopic devices similar in principle to those used in shoe stores to observe whether a good fit has been obtained. When a fluoroscope is used, the subject takes bismuth with the preceding meal so that the contents and activities of his stomach and intestines will be visible.

166

Measuring Some Physiological Concomitants of Emotion

The polygraph is registering the onset of the stimulus and also seven aspects of physiological reaction. Electroencephalograms are being picked up from the instrument on the subject's head. The pneumographs around her chest and abdomen provide records of thoracic and abdominal breathing. Below one knee is a sphygmomanometer, which picks up changes in pulse rate as well as blood pressure. Changes in electrical resistance of the skin are picked up from electrodes on the hand and sent into a psychogalvanometer connected with the recording polygraph. Changes in skin temperature are also recorded. An instrument for picking up tremors in the fingers may be used. Limb volume is sometimes recorded by using a plethysmograph. A wire recorder is shown at the extreme right. (From the Harvard University Department of Social Relations. Photo courtesy of Look.).

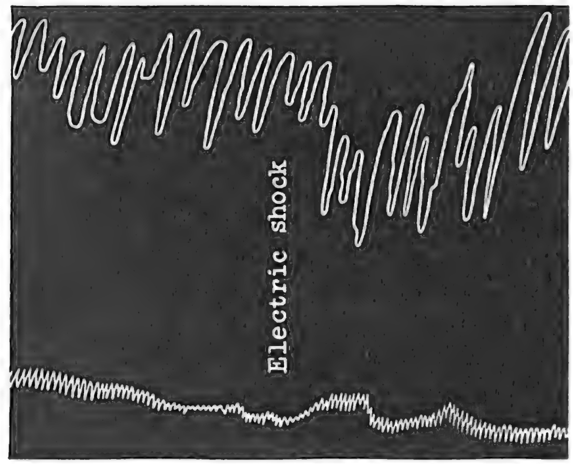
Another method of studying gastric functions involves observation of the stomach directly. A recent study of this nature had as subject a man whose esophagus had been closed off in childhood by drinking scalding clam chowder, and who fed himself through a gastric fistula.[35] This man put his food in his mouth, chewed it, and then expectorated it into a kitchen funnel inserted, through the fistula, into his stomach. Part of the gastric mucosa was turned outward in producing the fistula, so that circulatory changes in the stomach wall could be observed directly. The contents of the stomach could also be withdrawn at intervals for study. Conveniently, the subject was employed in the medical laboratory where the studies were carried out.

The patient suddenly experienced fear one

morning in the midst of a phase of accelerated gastric function. An irate doctor entered the room muttering imprecations about an important protocol which had been lost. The patient had mislaid it and feared that he had lost the record and his job. He lay motionless on the table and his face became pale. Prompt and decided pallor occurred also in his gastric mucosa, and associated with it there occurred a fall in the rate of acid production. A minute later, the doctor found his paper and left the room. Forthwith the face and gastric mucosa of the patient regained their former color.

A different reaction occurred at another time, when a doctor who complained of the patient's work told him he need not report for work any more. The subject accepted the rebuff politely. However, "his stomach became red and engorged and soon the folds were thick and turgid. Acid production accelerated sharply and vigorous contractions began." This subject showed such reactions whenever he became anxious, resentful, or hostile.

Other physiological aspects of emotional behavior — aspects like basal metabolism, blood count, blood sugar, hormones in the blood, skin temperature, urine sugar, and the like — are measured with the various devices used in clinical medicine. Many of the changes thus measured are directly or indirectly related to the concentration of adrenalin in the blood. Adrenalin is a hormone secreted by the adrenal glands located one above each kidney.



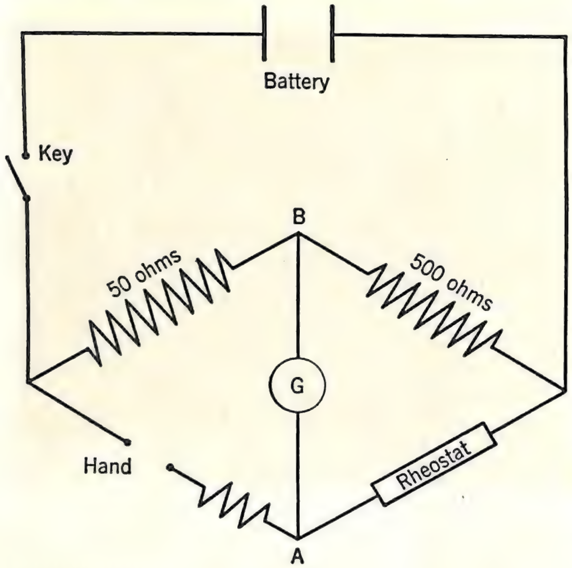
167 **Some Respiratory and Circulatory Changes in Emotion**

Read from left to right. The subject was given a strong electric shock on the hand. Almost immediately after, as indicated in the record, his inspiration (lowering of the upper curve) became deeper. The respiration curve increased in amplitude. The blood pressure showed a slight rise, and the pulse increased in amplitude and to a slight degree in rapidity. This should not be taken as a typical reaction to shock, for curves made under these circumstances differ greatly from subject to subject and in the same subject from time to time. All that this curve illustrates is the general nature of respiratory and blood-pressure curves and the most obvious ways in which changes in them may be analyzed.

Adrenal discharge in emotion

Adrenalin in excess amounts produces such effects as an increase in blood sugar, due to release of glycogen from the liver; sugar in the urine, as in mild diabetes; speeding up of heart action; constriction of small blood vessels in the skin; increased blood pressure; and more rapid clotting of the blood. Cannon, who has done a large volume of research in this field, points out that the increased energy made available through higher blood sugar, together with some of the other physiological effects of excess adrenalin, has an emergency function. Excess adrenalin and related effects are presumably responsible for the almost superhuman feats of speed and strength which individuals sometimes put forth in emergencies, and which may enable them to escape dangers. Increased coagulability of the blood has obvious value in situations involving injury to the organism.[36]

Although adrenalin produces changes such



168

A Simple Psychogalvanometer

In this adaptation of a Wheatstone bridge, the subject's hand and an adjustable resistance (rheostat) are connected with two arms of the bridge, while fixed resistances of respectively 50 and 500 ohms are connected with the other arms. The potential in point B *of the bridge corresponds to the ratio 50:500 or 1:10. When the resistances of the subject and the rheostat are also in the ratio of 1:10, the potentials at* A *and* B *balance and there is no deflection of the galvanometer. The rheostat is adjusted so that this is the case. Now the subject is the only variable. Any change in the electrical resistance of his skin will lead to a change in potential between* A *and* B. *The needle of the galvanometer will then swing out of balance.*

as we have mentioned, injection of the hormone under non-emotional circumstances does not necessarily arouse emotional experience or behavior. Among twenty-two normal subjects injected with adrenalin, three reported unpleasant experience, one pleasant experience, ten no emotional experience at all, and the remainder a variety of emotions. Subjects injected with adrenalin often report that they feel as if they were going to have an emotional experience, but the expectation is not usually realized.[37] This probably means that, in addition to the physiological changes produced by adrenalin, an emotion-provoking situation and related postural activities are usually necessary for the arousal of emotional experiences.

The galvanic skin response

This response is studied with the so-called *psychogalvanometer,* which measures changes in electrical resistance in the skin — electrodermal changes. These changes are now known to result from activity of the sweat glands. At one time psychologists thought the *galvanic skin response* or G.S.R. was specific to emotion — that is, present only when emotion was aroused. It has been clearly established, however, that the response also occurs in manual and mental work. However, the G.S.R. is clearly present in emotional upset, and may even provide a rough measure of the degree of upset.[38]

Many psychogalvanometers involve the principle of the Wheatstone bridge, illustrated in Figure 168. The subject is placed in one circuit, the potential of which may be balanced with that of a fixed circuit. The two circuits are connected through a galvanometer. When they balance, the galvanometer reading is zero. If the subject's skin resistance changes, however, the potentials are thrown out of balance and a deflection of the galvanometer results.

Changes in the galvanometer following emotional stimulation are due to a lowering of electrical resistance between the two electrodes on the skin. This lowering of electrical resistance is itself due to the fact that beads of sweat oozing out of the skin facilitate conduction of the current. A record obtained with a mirror galvanometer, which throws a spot of light on a constantly moving photographic film, is shown in Figure 169. The G.S.R. may be studied in terms of its latency (how long a period elapses before the change occurs), its amplitude (degree of

change from zero), its duration (the time which elapses between onset of the response and the return to normal), or some derivative of such indices.

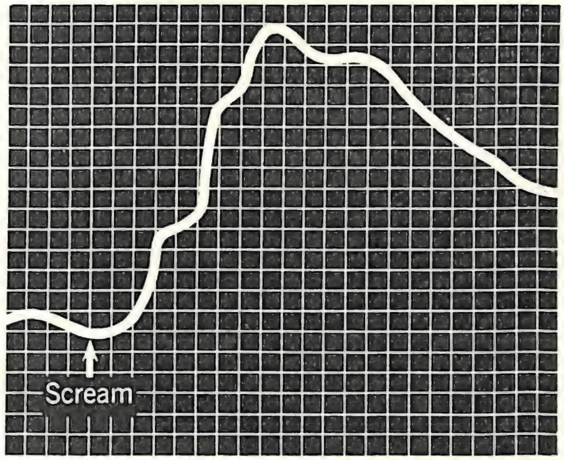
Differentiating emotional from non-emotional states

We have seen that emotion has varied physiological concomitants, many of which are objectively measurable. Is it possible, by studying such changes, to tell whether or not the individual has been emotionally aroused? Can we tell anything about the intensity of emotional arousal?

The so-called lie detector discussed in the following chapter exemplifies the fact that physiological changes sometimes indicate whether or not, and, if so, to what degree, an emotional reaction has been elicited.

Perhaps the best-known laboratory diagnosis of emotional response is that in which eighteen college students volunteered to serve as subjects in an experiment allegedly concerned only with studying their heart action. One at a time, they sat in a dark room with an electrocardiograph, a pneumograph, and a psychogalvanometer attached to them. The experimenter remained in an adjoining room. Three records were taken without anything unusual happening. At the fourth session, however, the experimenter threw a switch, and the chair unexpectedly fell backwards through an arc of sixty degrees, after which its fall was gradually absorbed by a door check. The subjects let out a yell, called for help, or tried to escape from the situation. All reported experiencing fear and said that the collapse was entirely unexpected. The same subjects and three others were later subjected to the falling-chair situation, but with the knowledge that the fall would occur. They had no warning, however, as to just when it would come. None of the subjects reported fear under these circumstances.

A comparison of the records obtained when fear was present and when it was ab-



169 **Galvanic Skin Response to a Scream**

The record was obtained by photographing the successive positions of a spot of light reflected from the mirror of a galvanometer placed in the electrical circuit of the psychogalvanometer. (From Lund, F. H., Emotion. *New York: Ronald, 1939, p. 185.)*

sent shows that, although all of the physiological reactions which were recorded had changed, the change was in some instances greater when the fall was unexpected and fear was experienced than when it was expected and no fear was present. For example, initial acceleration of the heart was 16 per cent under the first circumstances and 10 per cent under the second, and the duration of the change in rate of breathing was three minutes under the first circumstances and one minute under the second. The psychogalvanic reaction was about the same under both circumstances. Several of the respiratory and circulatory indices were not significantly different in a fall with fear from a fall without fear.[39]

It is necessary to add a note of caution at this point. In studies of physiological expressions, the investigator knows that an emotion-provoking stimulus has been presented, hence he can correlate physiological changes with such stimulation, and with emotion as

reported by the subject. Under such circumstances someone else who knows that the subject has been emotionally aroused may, from the physiological record alone, be able to tell at what point the subject became emotionally aroused. However, physical and mental work often produce physiological changes like those associated with emotion. Thus, if one saw a record of respiratory, circulatory, and electrodermal changes without knowing whether work or emotion was involved, the chances are that he would be unable to deduce which had produced the changes — work or emotion.

General observation and evidence from the laboratory suggest strongly that, whatever emotion is aroused, a more intense arousal (in terms of intensity of stimulation and reports of the individuals concerned) brings more marked physiological changes than a less intense arousal. In this connection there is some evidence that the intensity of affective arousal is correlated with the magnitude of the G.S.R. For example, those stimuli which the individual rates as pleasant or unpleasant tend to arouse a more marked galvanic reaction than those rated as neutral in affective value.[40] A high intensity of emotion (as reported by the subject) is also usually associated with a more marked galvanometer deflection than is a weak intensity of emotion.[41]

Does each emotion have its own distinct physiological characteristics?

There are really two problems here. The first is to discover whether the direction and degree of change in a particular physiological process, or aspect of a physiological process, is different for different emotions. In other words, does respiration differ in, let us say, fear and anxiety? The second question poses a more difficult problem — that of discovering whether the great variety of physiological changes associated with a particular emotion fall into a given pattern which may be differentiated from the pattern of some other emotion. If the physiological patterns associated with fear and love were distinct, and similarly distinct from physiological patterns in other emotions, we should be able to deduce that fear or love was present merely from a study of the recorded physiological changes.

The answer to the first question is that little success has been achieved in differentiating emotions in terms of changes in a particular physiological variable. Most of the results are negative. Sexual passion or lust, the emotion intimately associated with the heights of sexual activity, of course presents a unique case, since physiological reactions in the sex organs are especially involved.[42]

The answer to the second question is that a large amount of research on this problem has disclosed no distinct pattern of physiological changes which would enable us to differentiate one emotion from another. However,

> . . . attention should be called to the distinction between emotions as physiological states and emotions as enumerated and described in our descriptive terminology. As determined by the latter, our emotions are quite numerous. Consider, for instance . . . fear, horror, disgust, repulsion, aversion, dislike, annoyance, anger, sadness, sorrow, despair, hopelessness, pity, sympathy, hunger, interest, curiosity, pleasure, delight, fascination, admiration, amusement, humor, affection, love, tenderness, and passion.
>
> It should be apparent that these terms are not descriptive of so many internal or organic states. They are descriptive, in most cases, of objective situations and of accepted modes of handling and dealing with these. Despair and annoyance could not be recognized, except in terms of certain behavior forms or certain external conditions. Even where the impelling features of an emotion are internal rather than external, our descriptive terminology has reference to the overt rather than the visceral component. This is true of fear and anger. These emotions are distinguishable, not in terms of their visceral

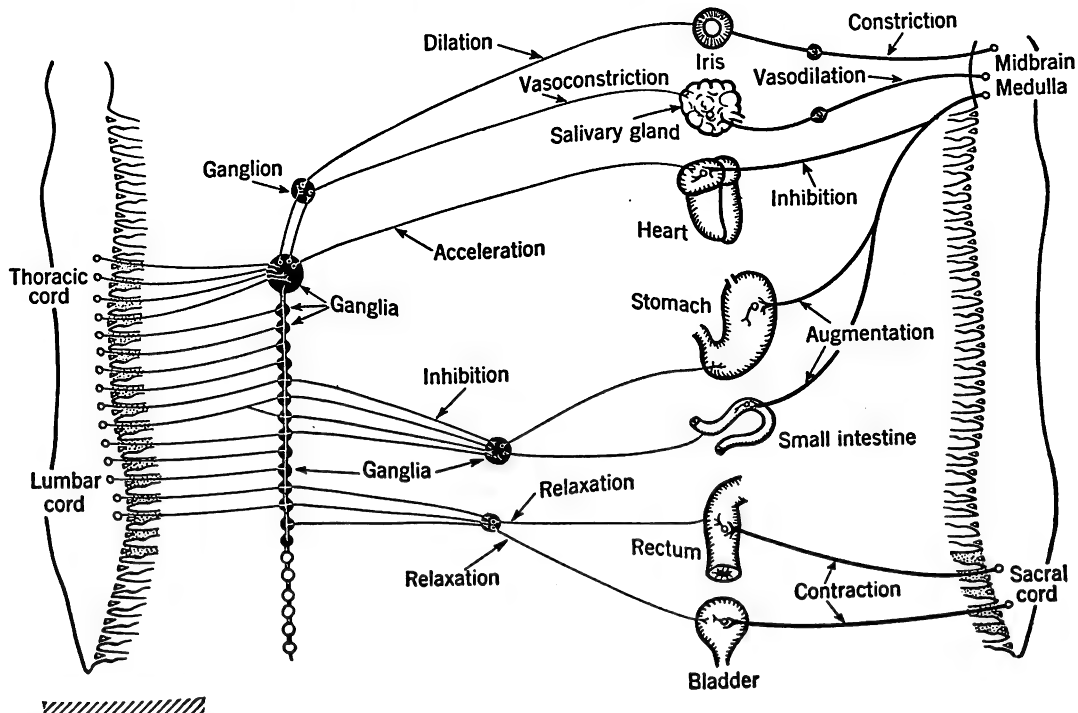
component, but in terms of their overt features, fear being a tendency to withdraw or flee, anger being a tendency to strike or attack.[43]

NEURAL MECHANISMS IN EMOTION

Emotion is a function of the whole organism — when we are emotionally aroused, we are aroused all over. Nevertheless, certain parts of the organism are more intimately involved, and involved to a greater degree, than others. What applies to the organism in general also applies, of course, to the nervous system in general. Our peripheral and central nervous systems are involved. Afferent and efferent fibers connecting the spinal cord and brain stem with the skeletal muscles and the autonomic nervous system are involved, as well as all the structures of the brain stem and the cerebral cortex. Nevertheless, the neural structures most intimately involved in emotional behavior and experience are the *autonomic nervous system*, the *hypothalamus*, and the *cerebral cortex*.

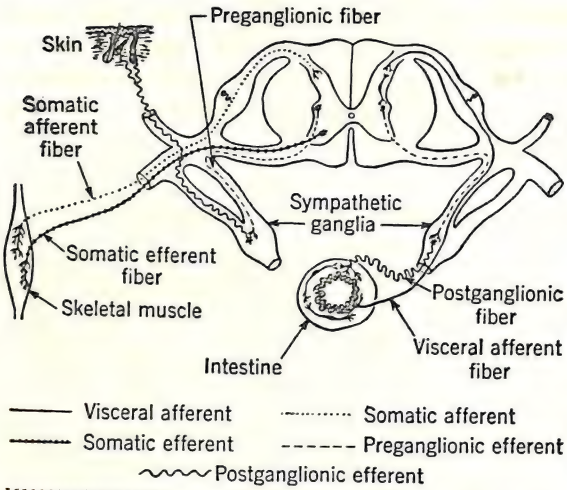
The autonomic nervous system

As we observed on pages 55–56 of our discussion of response mechanisms, the autonomic nervous system has two main divisions, the *sympathetic* and *parasympathetic*. Most of the visceral and other internal structures have dual connections, one with the sympathetic and one with the parasympathetic. These systems work in opposition so that, if one accelerates an organ, the other has an inhibitory effect. Some of these antagonistic relations are illustrated in Figure 170, where the sympathetic connec-



170 **Schema to Illustrate Antagonistic Action of Sympathetic and Parasympathetic Impulses**

For simplicity in presentation, the sympathetic fibers are illustrated by the lighter lines to the left of the figure. The parasympathetic fibers are represented by the heavier lines to the right. (After Hunter, G. W., and F. R. Hunter, College Zoology. *Philadelphia: Saunders, 1949, p. 555.)*



171

Diagram Showing Afferent as Well as Autonomic Connections with the Central Nervous System

Note that the intestine, for example, is activated by postganglionic efferent fibers of the sympathetic system and that impulses are conveyed back from it over visceral afferent fibers. Parasympathetic connections are not shown. Activation of the skin by the sympathetic fibers (sweating and hair erection) is also illustrated as is the somatic reflex arc. (Modified from Turner, C. D., General Endocrinology. *Philadelphia: Saunders, 1949, p. 214.)*

tions are shown as though coming from the right and the parasympathetic as though coming from the left of the spinal cord. Observe, for example, that the iris (pupil) is dilated by the sympathetic and constricted by the parasympathetic and that stomach activity is inhibited by the sympathetic and augmented by the parasympathetic.

The autonomic system, as such, is motor (efferent), but, as shown in Figure 171, many organs also have sensory (afferent) connections with the spinal cord. Thus their activities arouse impulses which enter the spinal cord and travel to the brain.

Stimulation of any part of the sympathetic system tends to bring about a widespread effect, inhibiting or accelerating the functions of most of the related structures. Part of this diffuse effect is due to the involvement of the adrenal glands. In other words, the sympathetic system activates these glands which, through their discharge of excess adrenalin into the blood stream, produce reverberations throughout the whole body.

There is no doubt that most of the visceral components of emotion are dominated by the sympathetic division of the autonomic system. Until recently, the parasympathetic system was thought to be completely "silent" during emotion. However, recent investigations on animals have shown that some structures are dominated by the parasympathetic, even when the organism is emotionally aroused. The conclusion thus forced upon us is that "emotion is characterized by autonomic function rather than by sympathetic function alone." [44]

The hypothalamus

It has long been known that accidental or experimentally produced injuries to the thalamus may produce marked changes in emotional behavior. Sometimes the effect is to make the individual apathetic; at others it is to heighten emotionality. Apathy occurs when the *hypothalamus* (Figure 25) is seriously impaired; heightened excitability occurs when this region is intact, but connections between it and the cerebral cortex, through the thalamus proper, have been cut. The latter is presumably brought about by removal of the inhibitory effect of the cortex.

The recent emphasis by physiologists on the hypothalamus as a center for control of emotional behavior grows out of experiments on animals. Stimulating the hypothalamus with a needle electrode causes a cat to "retract its ears, crouch, growl, raise its back and lash its tail, and show a crescendo of . . . typical sympathetic and motor reactions."[45] Removal of the hypothalamus abolishes all expressions of emotion in cats and dogs,

whereas removal of no other part of the brain has this effect.[46] Drugs, such as sodium amytal and metrazol, which act specifically upon the hypothalamus, produce marked changes in the emotional behavior of animal and human subjects.[47]

Such observations as these make it evident that the hypothalamus plays an important role in emotional behavior, but they do not justify the conclusion that it is the only important neural mechanism for control of emotion. In the first place, the seemingly emotional reactions produced by stimulation of the hypothalamus differ markedly from naturally aroused emotional behavior.

> . . . much as these reactions resemble those of rage and fear, they differ from the latter in certain significant respects. For instance, the ostensibly aggressive activity during hypothalamic stimulation is not directed toward specific objects in the animal's environment, even when these are manipulated so as directly to irritate the animal. Again, the responses induced by hypothalamic stimulation are not adapted to the surroundings; *e.g.*, the cat will dash itself repeatedly against the sides of the cage and neglect a readily available avenue of escape. Moreover, all of the pseudo-affective reactions cease abruptly at the end of the stimulus, without leaving any of the residue (mewing, trembling, hiding, and the like) ordinarily observed after true emotional states. In effect, the activity induced by hypothalamic stimulation is mechanical, diffuse, stereotyped, stimulus-bound, and seems to carry no greater emotional connotation than would the contraction of a skeletal muscle induced by the stimulation of an efferent nerve. On these phenomenological grounds alone, then, pseudo-affective reactions differ significantly from those in motivationally determined emotional states.[48]

Although it is clear that the hypothalamus plays a role in the motor expressions of emotion, its role in relation to feeling aspects is widely disputed.[49]

The cerebral cortex

In considering the role of the cerebral cortex in emotion, four facts stand out: (1) Most emotion-provoking situations cannot be perceived without the cortex. (2) The cortex plays a major role in adjustment to emotion-provoking situations. The cat or dog, with its cerebral cortex removed or seriously impaired, shows a decreased ability to avoid injury, escape from danger, or vent its rage appropriately. (3) Another contribution of the cortex is the sustaining of emotional behavior after the emotion-provoking stimulus has gone. The organism devoid of a cortex ceases its emotional reaction as soon as the stimulus is removed, but the normal animal continues to react emotionally. (4) Removing the cerebral cortex increases the intensity of emotional expression. This widely verified observation is consistent with the well-known fact that the cerebrum exerts an inhibiting influence over other neural mechanisms, including the hypothalamus.[50]

THEORIES OF EMOTION

The two most prominent theories of emotion attempt to explain how emotional experience is generated. The *James-Lange theory*, named after its principal propounders, argues that emotional experience is the feeling of bodily changes. It rejects the commonly held view that emotion, as experienced, produces these changes. The *thalamic* or, more specifically, the *hypothalamic theory*, was developed by two physiologists, Cannon and Bard. It supposes that rather than one being the cause of the other, both emotional experience and emotional behavior are independently aroused by discharges from the hypothalamus.

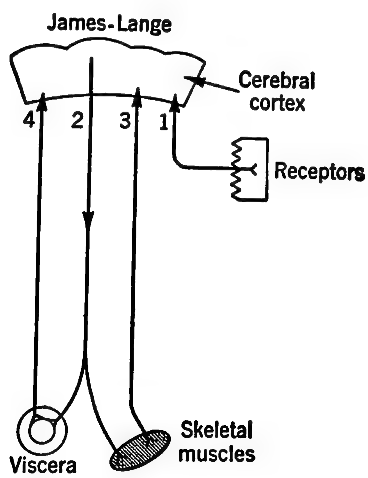
The James-Lange theory

William James[51] has formulated this theory as follows:

> My theory . . . is that the bodily changes follow directly the perception of the exciting fact, and that our feeling of the same changes as they

occur is the emotion. Common sense says, we lose our fortune, are sorry and weep; we meet a bear, are frightened and run; we are insulted by a rival, are angry and strike. The hypothesis here to be defended says that this order of sequence is incorrect, that one mental state is not immediately induced by the other, that the bodily manifestations must first be interposed between, and that the more rational statement is that we feel sorry because we cry, angry because we strike, afraid because we tremble, and not that we cry, strike, or tremble because we are sorry, angry, or fearful, as the case may be. Without the bodily states following on the perception, the latter would be purely cognitive in form, pale, colorless, destitute of emotional warmth. We might then see the bear and judge it best to run, receive the insult and deem it right to strike, but we would not actually feel afraid or angry.

Certain more specific aspects of the James-Lange theory are presented diagrammatically in Figure 172. According to this theory, impulses aroused by the emotion-provoking situation (bear) go (via 1) to the cerebral cortex and from there (via 2) to the viscera and skeletal (external) muscles. Skeletal and visceral reactions arouse impulses which pass up to the cortex (via 3 and 4). These impulses add emotional feeling to what was previously mere perception. This theory takes no cognizance of thalamic connections such as actually exist, tacitly assuming that they have no emotional significance.



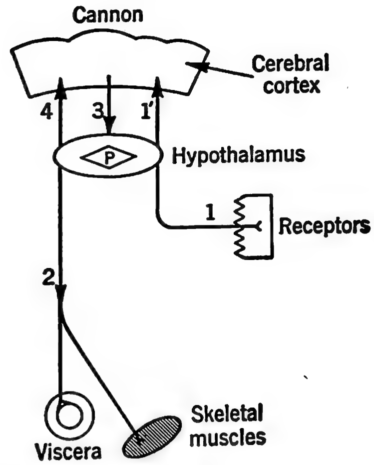
172

A Schematic Representation of the James-Lange Theory of Emotion

For explanation, see the text. (After Cannon, W. B., "Again the James-Lange and Thalamic Theories of Emotion." Psychol. Rev., *1931, 38, p. 282.)*

In support of this theory, James mentions such alleged facts as the following: Unless one assumes the postures typical to an emotion he fails to have the emotional experiences. In other words, it is claimed that if a situation calls for grief, and instead of slumping you hold your head high and stick out your chest, no experience of grief will come. On the other hand, it is argued that if you assume the postures typical in a certain emotion you will tend to have that emotion. James was told by actors that when they went through the postures of emotion and played their part well, they had corresponding emotional experiences. He also asks us to imagine an emotion without the heart palpitation, the goose pimples, and various visceral changes, and suggests that we will have little or no success in doing this.

While it is true that the experiential aspect of emotion sometimes obviously involves feelings of bodily changes (p. 345), emotions are experienced in which such feelings are not apparent. Sometimes the emotion is felt too rapidly to depend upon such changes. The visceral reactions are especially slow and after they occur, the impulses have a long route to the brain. When they are obviously felt, the visceral contributions are therefore added to emotional experience which is already present. Furthermore, as we have already observed (pp. 349–351), the visceral reactions do not fall into clearly defined patterns, one for each emotion as this theory would seem to require. Adrenalin, which plays an important role in producing some of the widespread visceral



173

A Schematic Representation of the Hypothalamic Theory of Emotion

For explanation, see the text. (After Cannon, W. B., "Again the James-Lange and Thalamic Theories of Emotion." Psychol. Rev., *1931, 38, p. 282.)*

and skeletal aspects of emotion does not necessarily elicit emotional experience when injected. Therefore, emotional experience seems to be something other than a mere "feeling of" visceral and skeletal activities.

Sometimes, as the result of accident, individuals have their spinal cord severed in the neck region. Although they survive for a time, these people are paralyzed from the neck down. Lower skeletal contributions to emotion would thus be cut off, as, also, would be impulses from much of the visceral region. Nevertheless, typical emotional experiences are reported.[52]

These and other data too detailed for presentation here cast serious doubt upon the validity of the James-Lange theory, plausible as it seems at first glance. Some bodily changes are felt, hence they do contribute to emotional experience as supposed by this theory, but it goes too far in supposing that there can be no emotional experience except the feeling aroused by visceral and skeletal changes.

The hypothalamic theory

As we have already suggested, this theory differs from that of James and Lange chiefly in its emphasis upon the independence of emotional experience and emotional behavior. Its assumption that both behavior and experience are independently aroused by activities in the hypothalamus is illustrated schematically in Figure 173. It is assumed that the sensory impulses (1 and 1′), while passing through the thalamus on their way to the cortex, arouse definite (inborn and acquired) patterns (P) of hypothalamic discharge. Impulses originating in the hypothalamus then go simultaneously to the cortex (via 4) and to the viscera and skeletal muscles (via 2). Path 3 represents the cortico-thalamic path, the impulses from which have an inhibitory influence upon hypothalamic discharges.

This theory, as well as that of James and Lange, recognizes the fact that emotion-provoking impulses may start from the cerebral cortex, as when thought processes give rise to emotion.

One can see quite readily that the hypothalamic theory overcomes the difficulties inherent in the James-Lange theory. The severing of the spinal cord in the neck region would not interfere with the discharge of the hypothalamus to the cortex, and hence with emotional experience. The injection of adrenalin would arouse visceral reactions, but not necessarily cause the hypothalamus to discharge. That visceral and skeletal reactions do not fall into discrete patterns, one for each emotion, would offer no difficulty for the theory. It supposes that emotional experience is due to hypothalamic discharge and not to visceral or skeletal activities. The fact that the viscera are relatively insensitive and slow to react would be of no account as far as the theory is concerned, for emotional experience is independently aroused.

The thalamic theory runs into serious difficulty, however, when attention is turned to

the facts mentioned above in connection with hypothalamic functions. In the first place, emotional behavior aroused by stimulation of the hypothalamus is less oriented toward a situation, more restricted, more stereotyped, less adaptive, and shorter-lived than naturally aroused emotional behavior. This suggests that parts of the nervous system in addition to the hypothalamus are significantly related to emotional behavior. From the standpoint of adaptation to emotion-provoking situations, the cerebral cortex is especially important. In the second place, as reported above, there is little or no reliable evidence that hypothalamic functions contribute to emotional experience in ways suggested by the theory.

We must conclude, therefore, that neither the James-Lange theory nor the hypothalamic theory is completely satisfactory as an explanation of the relation between emotional experience and emotional behavior. That we are often aware of bodily changes in emotion, whether or not these are necessary aspects as demanded by the James-Lange theory, shows that visceral and skeletal components play their part. We therefore cannot throw out the James-Lange theory altogether. Nor can the hypothalamic theory be ignored, for the hypothalamus, whether or not it is *the* center for emotion, contributes a great deal to emotional behavior. A theory in keeping with all of the known facts would not only have to combine certain features of both theories, but have to add a great deal besides.

SUMMARY

Emotion has experiential, overt behavioral, and physiological aspects. The experiential aspects have been studied by psychologists, but without providing descriptions as rich as those which have come down to us through poetry and other literature. Descriptions coming out of the psychological laboratory often do little more than name the emotion felt, indicate whether it was pleasant or unpleasant, and refer to such physiological activities as palpitation of the heart, "sinking" of the stomach, sweating, and trembling.

This chapter has laid particular emphasis upon the behavioral, including physiological, aspects of emotion. The development of emotional behavior in children has been subjected to intensive study. We have seen that the human newborn probably has only one emotional response; namely, general excitement. As the infant grows, he gradually increases his repertoire of emotions and specific emotional reactions. During the first two years of life, it is possible to discern the gradual emergence of several emotions. Moreover, the child who could only cry and thrash his limbs at birth comes to reach for objects, throw them, plead, complain, and manifest many other reactions when he is emotionally provoked.

The occasions for emotional upset tend to decrease as the child learns to master his environment. Nevertheless, objects which previously aroused no emotional reactions often come to do so. Thus, he may develop fear of snakes, of the dark, and of particular persons.

The facial and postural aspects of emotion soon conform, more or less closely, to the expressions which characterize members of the child's own group. The American child opens his eyes and mouth when surprised, but the Chinese child learns to stick out his tongue.

Some aspects of emotional development are undoubtedly due to maturation. This is especially true of crying, weeping, laughing, and certain other relatively simple reactions. Such responses appear even when, as in the congenitally deaf and blind, there are no opportunities to learn them.

Among the learned emotional reactions we find those which, while not common to mankind, characterize a particular culture. Reactions such as throwing, pleading, and complaining are also learned. Many of them are not specifically emotional, but are used by the individual in his adaptations to both emotional and non-emotional situations. The potency of particular objects and situations to arouse emotion is also developed through learning.

Turning our attention to the situational aspects of emotion, we observed that the emotion-provoking potency of a particular object or situation varies as the child grows older. Some situations have no emotional effect at all on a baby, but a marked effect on an older child. Conversely, certain other situations arouse emotion in a baby but not in an older child. Some stimuli increase and then decrease in emotion-provoking effectiveness as the individual grows older. In discussing situational aspects of emotion, we called attention to factors conducive to arousal of such emotions as fear, anger, humor, happiness, affection, jealousy, and sympathy.

Although facial and postural expressions of emotion probably have certain inborn aspects, an inborn "core," they involve such a mixture of culturally acquired and personal components that the "natural" expressions are not clearly recognizable. Ultra-rapid motion picture photography, which has made possible a differentiation of the learned and unlearned features of startle, has not yet been applied to typical emotions.

The physiological concomitants of emotion are studied through chemical tests of blood and urine and also by use of such instruments as the pneumograph (respiration), sphygmomanometer (blood pressure and pulse), plethysmograph (limb volume), electrocardiograph (heart-muscle activity), and the psychogalvanometer (electrical resistance of skin, or sweat-gland activity). Records obtained in emotion-provoking situations show that a variety of physiological changes, including secretion of adrenalin, accompany emotion. Similar changes also accompany many non-emotional states. If one knows that emotion-provoking stimulation has been applied, he can often discern, from the record of physiological changes, when the emotional response occurred. So far, however, little success in discovering distinct physiological characteristics for each emotion has been achieved. Similarity of physiological reactions in different emotions is much more evident than a difference in such reactions for different emotions. There is evidence, however, that stronger emotional upsets, as they are experienced and as they are manifested in overt behavior, have more marked physiological concomitants than weaker ones.

Emotion involves the whole nervous system. However, there are three parts which are more intimately involved than others. These are the autonomic nervous system (both sympathetic and parasympathetic), the hypothalamus, and the cerebral cortex. Recent research has shown that, while the sympathetic nervous system tends to dominate in emotion, certain reactions remain under dominance of the parasympathetic. Research has also disclosed that the hypothalamus, once thought to be the center for emotion, has a limited control over emotional expression. Expressions aroused by stimulating the hypothalamus are different in several important respects from those aroused under emotion-provoking circumstances. The cerebral cortex contributes to the perception of emotion-provoking situations, to adjustment in emotional reactions after the external stimulus has gone, and to the inhibiting of emotional reactions.

Neither the James-Lange nor the hypothalamic theory is completely in accordance with available evidence. The James-Lange theory says that emotional experience is perception of bodily changes, both visceral and skeletal, whereas the hypothalamic theory says that emotional experiences and bodily

changes are independent of each other, but both dependent upon discharges from the hypothalamus. A completely adequate theory would undoubtedly include certain aspects of the James-Lange and thalamic theories, but it would add a great deal more than is involved in either theory.

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15 FEELING AND EMOTION IN EVERYDAY LIFE

Feeling in Everyday Life: Aesthetic preferences; annoyances • Judging Emotional Expressions: Eyes versus mouth; postural expressions • Lie-Detection • Emotion as a Factor in Disease • Controlling Emotion: Anger; fear; worry; some reactions to danger • Cultivating Emotional Maturity • Summary

CERTAIN ASPECTS OF FEELING AND EMOTION in everyday life have been subjected to extensive psychological investigation. Feeling, as we have seen, is an aspect of all reports of emotional experience. However, certain objects, individuals, and situations which do not provoke any marked emotional reactions may nevertheless impress us as pleasant or unpleasant. Or, they may, as the saying goes, "leave us cold." A knowledge of the things which please or annoy us is of great practical value for those who wish to control human behavior. Some of the research in this general field of investigation has concerned the colors, tones, odors, tastes, and combinations of these which, through their pleasing effects, influence our preferences.

Postural and facial expressions of emotion were discussed briefly in the preceding chapter. Our interest there was primarily in exploring the possibility that each emotion has a unique pattern — one which differentiates it from other emotions. In the present chapter, we focus attention on the agreement shown by members of our own society in judging what emotions are being expressed by those around them.

This chapter also includes a discussion of the so-called lie-detector, some consideration of the field of psychosomatic medicine, a survey of some studies on the control of emotional behavior, and some suggestions as to how one may foster the development of emotional maturity.

FEELING IN EVERYDAY LIFE

By and large, the colors, odors, and tastes which we prefer are those which arouse pleasant feelings. Our aversions, on the other hand, are for objects and situations which arouse unpleasant feelings. Thus, any investigation of preferences and aversions is, in large measure, also an indirect study of feeling.

A knowledge of the colors preferred by the greatest number of people is of great practical value not only in advertising, but in every field of business and industry involving color. But how can one discover the preferred colors or color combinations?

One method is to take the possible colors or combinations and ask a large representative group of people to place them in rank order, the most pleasant or most preferred at the top, the least pleasant or least preferred at the bottom, and the others at appropriate places between these extremes.

A second method is to have individuals rate the color on a rating scale, which may be a line with 10 (pleasant) at one end and 1 (unpleasant) at the other end and numbers from 2 to 9 distributed at equal inter-

vals between. By this method the individual first looks at the color and then checks an appropriate point on the line.

A third method is to pair every color with every other color an equal number of times and ask the subjects to choose one in every pair. However, an individual may have a right- or left-hand preference, tending, for example, to like what is on his right more than what is on his left. To counterbalance this tendency, each color is paired with every other color at least twice, once on its right and once on its left. This general method is known as that of *paired comparison*. Its advantage over the rank order and rating methods is that it insures a comparison of every color with every other color under comparable conditions.

When the paired-comparison method is used, some colors are chosen more often than others, and we rank them accordingly. Suppose, for example, that six colors were to be compared with each other in all possible combinations. The number of combinations would be determined by the formula $n(n-1)/2$ which gives us $6(6-1)/2$, or fifteen combinations. When we consider that each color must be presented as many times on the right as on the left, it becomes apparent that there are thirty possible combinations. The number of times that each color is chosen in all combinations is determined, and a corresponding rank assigned to the color. The highest rank is given to the color chosen most often. Each of the other colors may be ranked on a similar basis, with that chosen the fewest times given the lowest rank.

The rank assigned each color by different individuals differs a great deal, regardless of the method used to determine preferences. However, when the ranks, ratings, or preference scores assigned to each color by many individuals are combined, there is evident a high percentage of agreement as to the most preferred and least preferred colors. There is usually less agreement, however, concerning the rank of colors between these extremes.

When the brightness and saturation of colors is held constant, most native-born North Americans (both Negro and white) prefer blue to all other colors. Yellow is the least preferred color. These preferences are not present at birth, but develop with age. Moreover, they differ from one culture to another. Thus, color preferences are acquired through cultural contacts. The Mexican, in whose culture red plays a large part, comes to prefer red above all other colors just as we come to prefer blue.[1]

In the business world it is necessary to discover which color or pattern of cloth, what color combination in an automobile, and so on, is most preferred. Since many things are involved, apart from color as such — for example, color combinations and color and form — the results from the psychological laboratory, although they may be suggestive, cannot be applied directly. On the other hand, the special methods devised in research on color preferences are used in solving such practical problems.

The methods used to discover color preferences are also used in determining preferences for other aspects of sensory experience. In one study of the affective value of common odors, it was found that peppermint was the most pleasant and carbon bisulphide the least pleasant.[2] Manufacturers of perfumes often use the procedures mentioned to select from many possible combinations those which the consumers will be most likely to prefer.

Much of the work on taste preferences has dealt with intensity aspects. Thus, it has been found that sweet, the most preferred taste, is consistently rated pleasant, whether low or high concentrations are used. Salt, on the other hand, is rated slightly unpleasant in low concentrations, and the unpleasantness increases as the concentration increases.[3] One will recall, in this connection, our earlier discussion of taste, as related to

the hunger drive. Certain substances needed by the organism, and of which it has been deprived, acquire a high preference value.

Investigations in the field of sound have shown that simple tones are usually rated pleasant, although certain tones, depending upon the individual, may be rated more pleasant than others. The average pleasantness rating for tones ranging from low to high pitch declines as the tones get higher. For a given pitch, the pleasantness rating declines as the tone goes from medium to loud intensity.[4] In our culture, tonal combinations that are consonant usually get a high preferential rating and those that are dissonant usually get a low rating. It is, of course, true that one may become accustomed to dissonance, as in "jazz," and that its pleasantness may thus increase.

Aesthetic preferences

A large amount of research has been done to determine which pieces of music, geometrical forms, paintings, prose passages, poems, and color combinations individuals most prefer. One of the most interesting aspects of this research, however, has been the effort to discover why individuals exhibit preferences for one artistic creation as against another. In some instances, as in the field of music, there are doubtless certain aptitudes for appreciation. Aptitudes are considered in a later chapter, but it may be said at this point that, unless an individual has fairly good ability to differentiate pitch and intensity differences, his appreciation of music will be limited accordingly. Likewise, a color-blind individual could hardly appreciate some colorful painting as much as an individual with full color sensitivity. In addition to perceptual ability such as that indicated, appreciation of artistic creations is greatly dependent upon training. Many a college student with little interest in or appreciation of music has, for example, acquired an interest and appreciation through his college course in musical appreciation where the works of such composers as Mozart, Bach, Beethoven, Tschaikovsky, and Rimski-Korsakov were played and discussed. Perhaps not too unexpectedly, our aesthetic preferences and appreciations are also greatly influenced by what we know, or think we know, about the individuals who have created the music, the painting, the narrative, or the poem. In the case of music, the prestige of the performer is often an important factor underlying appreciation.

Psychologists have shown that the prestige of an artist greatly influences judgments concerning the artistic merit of his creation.

Ten pictures were obtained. Care was taken to employ pictures by unknown painters and to insure a considerable range of preference. A suitable title for each picture and a name for the artist were sought. Two paragraphs were devised for each picture and were attached to the mats. One set of paragraphs (designated as +) attempted to augment the rating, the other (indicated —) to decrease the rating. The + and — paragraphs were chosen in a random order to make up two sets, each containing five +'s and five —'s. While each rater viewed all ten pictures, he could read only one set of paragraphs.

Directions given to sixty-four college students who acted as judges were as follows: "You will see a number of photographic reproductions on this table. Each one bears a number. You are to give your judgment in the following manner: on a sheet of paper put down the numerals 1 to 10, indicating the reproductions of corresponding number; then use the following symbols for your judgment:

1 — very beautiful
2 — pleasing
3 — indifferent
4 — displeasing
5 — very unattractive

You are to judge the painting, not whether the reproduction is good or bad."

A sample of the two kinds of title follows:

Chinese Girl by Estha Hunt

"The painting that made Miss Hunt rise from obscurity to *Who's Who,* a work of beautiful design and brilliant richness of color." (From the sales catalogue of Messrs. Bryan, Bryan, and Bryan, London; they sold it to Mrs. Paul Dermoth, New York, for $80,000.)

"An interesting painting by a little American High School girl in Shanghai. It was awarded second prize at the annual exhibition of the Kai-Hungpau High School."

The picture mentioned above received an average rating of 1.5 (between very beautiful and pleasing) when the high-sounding title was attached and 2.0 (pleasing) when the other was associated with it, indicating that the group given the positive suggestion rated it more beautiful than did the group given the negative suggestion. Similar results were obtained for every other picture in the group of ten. Some of the subjects failed to read the titles. If all had read them, the group differences would doubtless have been larger.[5]

One investigation utilized prose passages attributed to different authors, but actually written by Robert Louis Stevenson. The results demonstrated that appreciation of what one reads, his estimation of its merit, is greatly influenced by a knowledge of who wrote it. If the passage was attributed to a writer who had great prestige in the eyes of the judge, it was rated better than if a passage of comparable merit was attributed to a writer of relatively low prestige.[6]

Annoyances

Various aspects of our environment, including other individuals and what they do, are often sources of annoyance. One psychologist made an intensive investigation of common annoyances, aversions, or irritations.[7] His initial procedure was to have 659 subjects of both sexes, and ranging in age from ten to ninety, make a list of the things which annoy them. These individuals listed a total of 17,800 annoyances. When duplications were eliminated, there were still 2581 annoyances. These were then classified as in the following table, which also shows the approximate percentage of all subjects listing annoyances under each class.

It is quite evident from the data in Table 7 that the things which annoy most are activities of other individuals. In one way or another, practically every annoyance is connected with the behavior or characteristics of others, including their clothes and manner of dress.

TABLE 7. CLASSIFICATION AND FREQUENCY OF COMMON ANNOYANCES

(After Cason)

Class	*Number and per cent of different annoyances*	
Human behavior	1523	59.0
Non-human things and activities (exclusive of clothes)	486	18.8
Clothes and manner of dress	320	12.4
Alterable physical characteristics of people	138	5.3
Persisting physical characteristics of people	114	4.4

When 507 of the most common annoyances were selected for further study and individuals were then asked to rate them in terms of their annoyingness, the most annoying items were found to be things such as the following:

See a person blow nose without a handkerchief
A person coughing in one's face
A person cheating in a game
To see a woman spit in public
Odor of dirty feet
See a child being harshly treated by adult

Since this investigation of common annoy-

ances, others have applied similar procedures to a study of the habits of college professors which prove most annoying to students.[8] We may expect similar studies of the annoying habits of ministers, husbands, wives, children, and others.

The practical value of such studies for those who wish to "make friends and influence people" is obvious. If ministers, teachers, wives, and others do not know what aspects of their behavior annoy their parishioners, students, or husbands, there is little that they can do to reduce their annoyingness.

JUDGING EMOTIONAL EXPRESSIONS

Look at the expressions of emotion represented in Figure 174 and label each in terms of the emotion being expressed. Then look at page 609 to see how closely your judgment agrees with that of a large number of subjects who made a comparable judgment. In each of these instances we have only the face to aid us in making a judgment, and a stationary face at that. It is quite possible that the task of judging emotion would be easier if we could see the face in action. In

174 **What Emotions are Represented by These Facial Expressions?**

many instances, moreover, we would be aided by a view of general body posture, including the position of the hands. We could tell whether the individual was trying to ward off some assailant, about to attack someone, or about to run away. In many instances, too, a knowledge of the situation, and especially what led up to it, would help us. In watching a movie, for example, we not only see the actor's facial and other expressions and hear what he is saying, but we also see the situation that he is involved in and what preceded it. The value of knowing what has gone before in judging facial expression becomes apparent when one enters a movie in the middle.

Psychologists have done a large amount of research on judgments of emotional expression. One method has been to have an actress or actor pose in such a manner as to simulate various emotions. Two of the facial expressions in Figure 174 were posed and two were aroused spontaneously under conditions of everyday life. Can you tell which two were posed? The chances are that you can. Check your judgment with the statement given in the note on page 609.

Posed facial expressions of emotion are not judged with a high amount of agreement between judges. In the first place, the judges often disagree with the person who did the posing as to the emotion expressed. Thus, in determining whether or not an individual has judged "correctly," one usually goes by the majority opinion, not by what the actor intended. In other words, if you judge an expression to be rage and more of those who made the original judgments said it was rage than said it was something else, your judgment is said to be correct. In the second place, one can judge "correctly" only a small percentage of posed expressions. For example, very few individuals can correctly judge as many as ten out of the group of thirty-two posed expressions from which expression 1 of Figure 174 was taken — that is to say, judge them in agreement with majority opinion.[9]

When spontaneously aroused expressions are used, there is sometimes very close agreement among judges as to the emotion expressed. In a study involving spontaneously aroused facial expressions,[10] three expressions produced from 86 to 97 per cent of agreement as to the emotions involved. We do not know actually what emotions are represented, for the pictures were taken from *Life* and the subjects were not contacted by the investigator, but the judges said that two of the expressions represented joy or happiness (which may be regarded as synonymous terms) and that the other represented terror, fear, or horror (which may also be regarded as synonymous, or approximately so). Such a high percentage of agreement among judges is rare. There is almost universal agreement, however, as to whether an expression represents pleasant or unpleasant feeling.

Why, when 90 per cent say that an emotional expression represents fear, are we not justified in jumping to the conclusion that the emotion is fear? If the one whose spontaneous (not posed) expression was being observed said that he experienced fear, we should have to accept his report as correct, and those who said that the expression represented fear would have made a correct judgment, even if there had been only one such judgment. We might conclude, of course, that the expression was not representative of fear — that is to say, not a common expression of fear. That we cannot accept majority opinion as correct may be illustrated by an actual experimental finding. Over 70 per cent of ninety judges said that a certain spontaneously aroused facial expression represented sorrow. However, when they saw the facial expression, posture, and situation involved, all but 2 per cent changed their judgment from "sorrow" to such judgments as "strain," "determination," and "fear." Which judgments were correct? We do not know, because the person involved did not report the nature of her emotion.

A

B

175

Emotional Expression in Art

These two works of art were used, as described in the text, for studying the relative emphasis put by the artist on eyes or mouth or face as a whole in depicting emotional expression. The works shown are details of (A) *"Man with a Beer Keg," by Frans Hals (London, Sotheby Collection), and* (B) *"The Dance," by Carpeaux (Paris, Opera). (Photos courtesy of the Fogg Museum.)*

Eyes versus mouth

In their attempts to portray emotional expressions, painters and sculptors, as well as actors, are confronted with this question: Shall I stress the eyes or the mouth, or attempt to obtain an over-all expression? According to one writer, painters tend to stress the eyes and sculptors the mouth. This alleged tendency led him to investigate the accuracy with which painted, sculptured, posed, and candid camera expressions of emotion are judged in terms of (1) the face as a whole, (2) the eyes, and (3) the mouth. If most subjects said that a particular expression when seen as a whole represented mirth (Figure 175, A), this was taken to be the "correct" judgment. Then judgments in terms of the upper or lower part of the face were called "correct" if they also named the expression as mirth. Frans Hals' "Man with the Beer Keg," for example, was judged "mirth" by 90 per cent of those who saw it as a whole. Of those who saw only the upper half, only 65 per cent judged it to be mirth. Sixty-three per cent of those who saw the lower half also judged it to be mirth. Agreement was greater in terms of the whole face than in terms of eyes or mouth. Moreover, the "accuracy" of judgment in terms of eyes or mouth alone did not differ significantly. In the case of the sculptured expression in Figure 175, B, 76 per cent said "mirth" in terms of the whole face, 43 per cent in terms of the eyes and 75 per cent in terms of the mouth. In general the results for the four kinds of material showed greatest unanimity of agreement for the face as a whole. Half expressions generally elicited less agreement than the whole face. On the average, judg-

NATURAL

ELECTRIC SHOCK
"It was painful and made me somewhat angry"

CRUSHING A SNAIL
"It was repulsive. You probably couldn't get everyone to do that"

SNAKE
"Slightly surprised and frightened. Not much though"

JOKE
"Not very funny but laughed because it's conventional"

POSED

176

Natural and Posed Emotional Expressions

The last pair illustrates the method of presenting the upper or lower half of the face alone. Although we illustrate this technique with the eyes for the natural and the mouth for the posed expression, all expressions, posed and unposed, were used sometimes with the eyes alone and sometimes with the mouth alone. (From Coleman, J. C., "Facial Expressions of Emotion." Psych. Monog., *1949, No. 296, pp. 10–11.)*

ments from the mouth and eyes were equally accurate. Nevertheless, some expressions, like that of Figure 175, B, were judged more accurately in terms of the mouth while others were judged more accurately in terms of the eyes.[11]

Motion pictures of posed and unposed expressions, as illustrated in Figure 176, yielded results very much like the above. Instead of judging the emotion expressed, the judges checked off, on a list of the actual situations, that which they thought elicited the expression in question. As in the experiments already described, the whole face brought the most agreement among the judges. The upper and lower regions gave about equally accurate judgments, on the average, but some situations were predicted better in terms of the eyes and others better in terms of the mouth. The mouth served as a better basis of judgment in the case of the posed than of natural expressions. Most of the judges implied that they judged by empathy — that is, by identifying, or "feeling themselves into" the expression and imagining what could have produced it.[12] Conventional expressions of emotion, as represented on the stage and in films, differ a great deal from one actor to another. Some use the forehead predominantly, some the eyes, and others the mouth.

Postural expressions

How do postures contribute to the accuracy of judging emotion? In Figure 177 are some postural expressions of emotion. What emotions seem to be present? Do you think that the postures contribute to recognition of the emotion expressed? The reactions of judges are represented in the note on page 609. How does your judgment compare with theirs? In one investigation along these lines, judgments based upon the face alone were compared with judgments based upon the face and posture combined. There was somewhat greater agreement when postures were included than when the face alone was observed. Another investigation used posed expressions of the hands and forearms alone. Highly conventional expressions (as in worship) were judged with a very high amount of agreement, while others that are not so conventional brought widely scattered judgments. Slightly greater agreement was obtained for moving than for still expressions.[13]

Postures and facial expressions are often combined with the voice, which gives an added basis for judgment. The lover, for example, not only expresses his emotion in face and gesture, but also in the tone of his voice and in the things he says.

LIE-DETECTION

The so-called "lie-detector" is an apparatus for detecting physiological changes while the subject answers certain questions concerning a crime. In some instances he is called upon to say the first word which comes to mind upon presentation of certain "key" words. Actually, there are several "lie-detectors" in use today. One of the best-known and most widely used is illustrated in Figure 178. It is a compact modification of pneumographic and sphygmographic devices like those mentioned in our earlier discussion (p. 346). This "lie-detector" also includes a device for measuring and recording electrodermal changes, the galvanic skin reflex. Some lie-detectors also have devices for measuring tremor in the fingers.

All records are made simultaneously on a moving tape by means of ink-recording pens. Marks placed on the moving tape as the interrogation proceeds enable the investigators to associate the questions and answers with physiological changes.

In Figure 179 is shown the record of a thief who later admitted having stolen nine hundred dollars. Note that key questions were interspersed with irrelevant ones, and that only the former led to changes in respiration, blood pressure, and pulse rate. When

1

2

3

177 **Can You Name These Emotions?**

the galvanic skin reflex is also recorded, significant changes are represented by a drop in the tracing, which indicates a decrease in electrical resistance (sweating) in the hand on which the electrodes are placed.

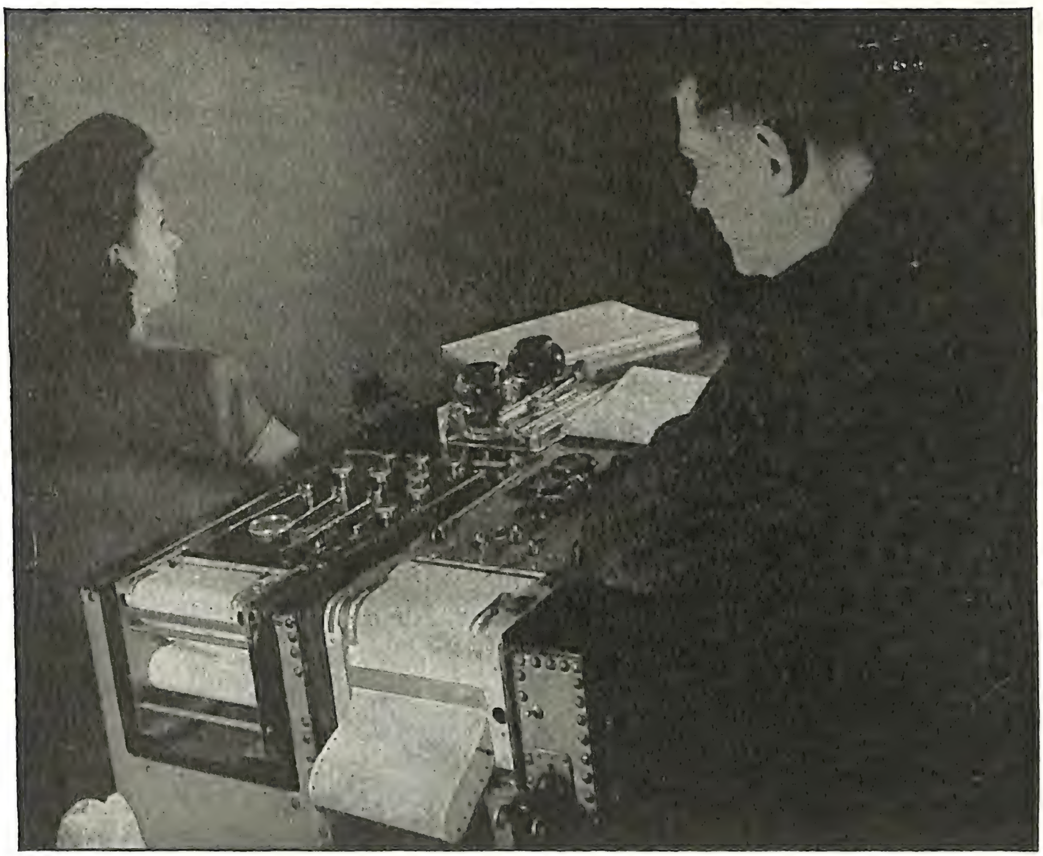
There are three common misconceptions about the lie-detector, namely: (1) that it is infallible, (2) that it really detects lies as such, and (3) that innocent people will react emotionally in the same way as the guilty.

Known criminals sometimes show no significant responses to key words. They may respond to key words in terms of one variable, but not in terms of others. For example, they may respond to key words in terms of blood pressure but not pulse rate, respiration but not blood pressure, and blood pressure and respiration but not galvanic skin reflex. Individuals sometimes succeed in "beating" the lie-detector. However, their obvious efforts to "beat" it are often in themselves a "give-away."

The lie-detector does not really detect lies. It detects emotional reactions in response to

questions. Presumably the innocent person would respond no more emotionally to key questions than to irrelevant ones. This would probably be true if he did not know anything about significant aspects of the crime. If he had read about them in the newspapers, for example, he might also react more markedly to key questions than to control ones. Whether the individual answers "yes" or "no" — whether or not he lies — is irrelevant, except for the fact that affirmative answers make the lie-detector superfluous. Actually, the stimulus which provokes the emotional reaction is the question itself — not the truth or falsity of the answer.

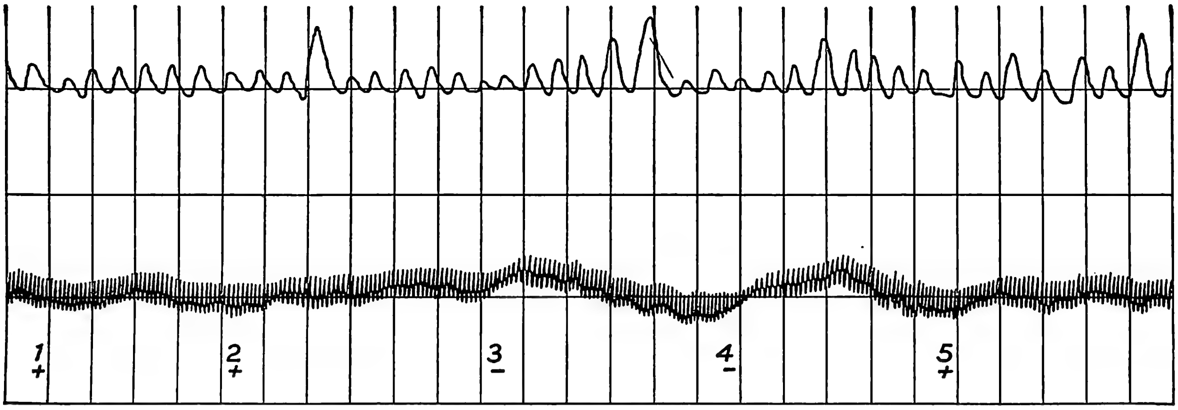
It is often claimed that anybody knowing that he was suspected of a crime would react emotionally to the lie-detector. The answer to this claim has already been suggested. It is given in the comparison of responses to key and control questions. For example, suppose we admit that a person is emotionally upset when being subjected to lie-detection tests. His blood pressure, respiratory, and galvanic response records show this emotional reaction by their general level. The significant thing, however, is not the general level of physiological reactions, but



178

A Lie Detector in Use

Here Leonarde Keeler, who devised the lie detector illustrated, questions a girl. Attached to her are devices like some of those pictured in Figure 166, p. 346. (Photo by Knopf from Pix.)



179

Record Obtained on a Thief Who Later Confessed Stealing $900

The upper line is a record of respiration and the lower line of blood pressure and pulse rate. Questions 1, 2, and 5 were irrelevant ("Is your name— ?"; "Do you live in Chicago?"; "Were you born in Illinois?"). At 3 the subject was asked, "Do you know who took the missing money?", and at 4, "Did you take it?" At 3 and 4 when the subject replied "No," observe the increase in blood pressure and the suppression in respiration. Moreover, the pulse beat, for about ten or fifteen seconds after the subject replied to 3 and 4, is somewhat slower than at 1, 2, and 5. The deviations at 3 and 4 from the subject's "norm," as established at 1, 2, and 5, are termed "specific responses." Numbers identify the questions and the plus or minus signs represent, respectively, "yes" or "no" answers. (From Inbau, F. E., Lie Detection and Criminal Interrogation. *Baltimore: Williams and Wilkins, 1942, p. 14.)*

the change in this level for key as compared with control questions. If the record shows significant changes for the former and not for the latter, guilt is at least strongly suggested.

Lie-detector records are not readily admitted as legal evidence either of guilt or innocence. Efforts to have them admitted have, in general, so far failed. Nevertheless, the lie-detector is a useful instrument from several angles. If the individual subjected to the test really believes that it can detect his lies, he sometimes confesses without undergoing the test. An individual confronted with a lie-detector record often feels that the "game is up" and confesses. Moreover, the results of the test are often useful to detectives in narrowing the number of suspects. If the lie-detector test obviously shows one suspect to be the culprit, efforts to obtain evidence may be concentrated upon him, his associates, and his previous activities.[14]

Somewhat akin to the lie-detector test in its outcomes is the free association test. This is sometimes used by psychiatrists to detect *emotional complexes.*[15] The individual may be asked to respond with the first word which comes to mind as each of a group of key and control words is given. The words selected may be taken from lists prepared by psychiatrists, or they may be made up in terms of information about the subject's past, his associates, and so forth. Evidence that a word has really "hit the mark" — that it has probed a complex — comes from such aspects of response as the following: slow response to key words compared with the response to irrelevant words, repeating the stimulus word, giving the same response to several stimulus words, inability to make a response, giving peculiar responses, and associated emotional reactions, such as blushing. These are often referred to as *complex indicators.* Sometimes the free association

technique is combined with measures of physiological changes.

Certain words, as "death," "kiss," "home," and "love," frequently arouse emotional reactions — so frequently, indeed, that psychiatrists have arranged standard lists. There are certain other words which, while they might not have emotional meaning for others, would have such for the individual with whose past experience they have been especially associated. For example, a psychology student who did not for a long time respond to the word "dance," and who showed other overt signs of emotion, later confided that he had undergone a very embarrassing experience while dancing. None of the other subjects responded emotionally to the word "dance."

EMOTION AS A FACTOR IN DISEASE

There is increasing evidence that many common gastrointestinal disorders (such as stomach ulcers and chronic constipation) are precipitated by chronic emotional states, especially anxiety. A relatively new field of investigation known as *psychosomatic medicine* has focused particular attention upon emotion as a causative factor, not only in gastrointestinal disorders, but also in many others, including allergies, certain kinds of aches and pains, and even more complex disorders.[16]

Much of the supporting evidence comes from case studies. For example, one study showed that, of seventy-five individuals suffering from critical stages of ulcer, sixty-three had been subjected to unusual emotional strain for some days earlier. Financial difficulties, family conflicts, and worry over illness played a prominent part in the background of these individuals.[17]

The most direct evidence of psychological factors in the origin of peptic ulcer is that obtained in an experiment on a patient whose stomach contents and lining could be observed.[18] This patient was mentioned in the preceding chapter (p. 346). During two weeks of sustained anxiety, the redness of the patient's stomach and his acid secretion both showed a marked increase. There were correlated complaints of heartburn and abdominal pain. Bleeding points appeared spontaneously and mucosal erosions and hemorrhages were produced on the exposed lining of the stomach, merely by tapping it with a glass rod or rubbing it with dry gauze. Under normal conditions, such bleeding points are quickly repaired by mucus. On the exposed surface, however, as in the duodenal cap under normal circumstances, there was little if any mucus to repair damage. To test the idea that continued acid irritation of erosions might produce ulcers, the investigators made a small erosion on the exposed stomach lining and bathed it continually for four days with the patient's own gastric juice.

Within twenty-four hours the denuded surface had increased in size. The base of the lesion became deeper, and it bled intermittently. At the end of four days it measured four millimeters in diameter and presented the punched-out appearance of a chronic peptic ulcer, with well-defined edges and a granulating base. Traction or pressure applied to the lesion caused pain. While this lesion was present the whole mucus remained relatively engorged, and acid production was maintained at a high level.

On the basis of this and other evidence, the investigators say:

> It appears likely . . . that the chain of events which begins with anxiety and conflict and associated overactivity of the stomach and ends with hemorrhage or perforation is that which is involved in the natural history of peptic ulcer in human beings.

Gastroduodenal disorders were reported to have played a large part in producing British casualties during early years of the recent war. Inadequate screening of recruits with a history of such disorders and army food admittedly played a role, but emphasis is given to "a markedly neurotic per-

sonality structure" and "prolonged tension of men mobilized for war and exposed to hostile action, but with little opportunity for combatant activity." [19]

CONTROLLING EMOTION

Many people who come to psychologists for help in solving their personal problems are much concerned about irrational fears, inability to avoid outbursts of temper, inability to control fits of jealousy, and worry over real or imagined deficiencies. Quite often, they expect the psychologist to listen to their story and offer forthwith some cut-and-dried formula for the solution of their problems.

A person's early history often holds the key to his problems of emotional control. How we act in emotion-provoking situations — how often we are provoked even — depends to a great extent upon childhood experience. The psychologist cannot undo in an hour or so, or sometimes even in weeks or months, the damage wrought by fears implanted and nurtured by parents, parental indulgence in the child's every whim, and other forms of unhealthy emotional conditioning. It should be obvious, therefore, that the most effective emotional control starts in childhood. Recognition of this fact does not help a great deal in controlling ourselves, but it may help in the emotional education of our children. Actually, there is no formula for the control of emotional behavior in adults. Each case, because of its peculiar history, requires a somewhat different treatment. In any case, re-education is required. It seldom happens that an individual is converted suddenly from a person lacking in emotional control to one possessing control. The process is long and slow, often requiring continued guidance from a psychological counselor.

Anger

Anger is not altogether undesirable since, as we have seen, it sometimes motivates people to remove such annoying things as graft, corruption, and social injustice. The journalistic "muck-raker," for instance, gets "things done" only when he makes people "mad." In most situations, however, anger is clearly to be avoided. The child especially must be trained to control his anger outbursts for the good of himself and others.

Forty-five mothers, enrolled in child-study courses, made systematic observations upon anger in their children. Among other things, they recorded the situations which precipitated anger, the frequency of anger outbursts, the degree to which such outbursts were blind or retaliative, how long the outbursts lasted, how they were terminated, and the nature of after effects such as sulking, sobbing, and resentment.[20] They also reported the age of the children, their health, and the methods used in an effort to control temper tantrums. As one might expect, frustration was usually the precipitating factor. Also to be expected is the fact that retaliation became increasingly important as the child grew older. The most interesting outcome from our standpoint, however, concerns methods of control and their effectiveness.

The parents involved in the present investigation reported spanking and many other methods of control, some used alone and some in association with others. When the data were analyzed in an effort to discover the most effective method, the outcome was far from conclusive. The chief difficulty was in setting up a criterion of effectiveness.

Is the most effective procedure that which most quickly terminates the tantrum? If so, bribery, granting the child's desire, diverting attention to something else, providing a substitute, ignoring the outburst, and isolation are quite effective in many instances.

Is the most effective procedure that which reduces the number of outbursts? If so, several of the above methods are far from

desirable. For example, bribery quickly concluded the outburst, but mothers who reported using this method reported a greater frequency of outbursts than did mothers who failed to use it. On the other hand, mothers who used spanking, a method which does not terminate outbursts as rapidly as bribery, reported relatively few outbursts.

Is the most effective method that which has fewest undesirable after effects, such as resentment and sulkiness? If so, spanking is much less effective than some other methods, for it is often followed by resentment and ideas of "getting even" with the parent.

It should be clear, therefore, that the investigation warrants no rule-of-thumb advice to parents on how to control anger outbursts in their children. As the investigator is careful to point out, there are many different ways in which the "same" method, such as spanking, may be applied. One spanking procedure may yield better results than another. It is pointed out, too, that much depends upon preventive methods.

Serenity and tolerance in the parent may avert or soften many frustrations, thus avoiding anger outbursts. Averting frustration is illustrated by the following examples:

A child came home from school with plans to attend an amusement park with several of her friends. Her parents felt that the park was not a fit place for young children to go unaccompanied. However, the children had made their plans. The next day, a school holiday, they were going early in the morning and were to stay all day. Many a mother would say, "You can't go!" — perhaps giving the reasons for her objections — and arouse antagonism. The mother in question solved the problem without eliciting the display of emotion which such parental frustration might arouse. She agreed to let the child go, then dropped the matter for a time. At the supper table, however, she said, "Mary, since you are going to —— park tomorrow and will be out all day, I think I'll go into town in the morning, do some shopping I've been wanting to do for some time, eat my lunch downtown, and go to see a movie. I'll be home in plenty of time to get your supper." The mother knew well enough the attractiveness of the respective alternatives. After a moment or two of hesitation, the child said, "Mother, do you suppose that I could go with you if I don't go to —— park?" The mother said, "Why, if you'd rather do that, we can go downtown together."

A child of three insisted that he was going to take his teddy bear to Nursery School. His father said, "All right, you may take it." Then, after a few minutes, the father said, "People are going to say, 'Look at that baby carrying a teddy bear to school.'" The child replied, "I'm not a baby. I'm a big boy!" Then he said, "I think I'll leave Teddy home, he might get a cold." His father knew that the desire to be thought a big boy was more potent than the desire to take the teddy bear.

The child should not, however, be shielded from all frustration.

> If we wish to train children to be even-tempered on most occasions and to reserve their anger for circumstances under which anger seems to be justified, we shall be most successful if we direct our attention to the impulses and attitudes from which behavior springs. Anger comes when a strong impulse or desire is thwarted. In a world made up of many people, the child who does not early learn the necessity for reasonable conformity to the rights and wishes of others, but must have his own way at all costs, is likely to meet with many difficulties that the more co-operative child will escape.[21]

Fear

Fear, like anger, sometimes produces a level of motivation which could hardly be produced without it. In training children to avoid dangers, fear is almost universally utilized, probably because it is easier to instil fear than to educate in a more positive manner. It is of course preferable, but more

time-consuming, to teach a child to look both ways and cross and recross streets under adult supervision than to tell him that he'll get hurt or killed if he runs out into the street. Many fears of course have no utility at all.

Some fears, like fear of snakes and of being disliked by others, are very common in human adults. Other fears, such as the fear of being buried alive, fear of enclosed spaces, and fear of women, are seldom encountered. The former fears are usually regarded, because of their frequency, as more or less normal. The latter, known more specifically as phobias, are classified as abnormal and given special names. The three examples are, in order, *taphephobia, claustrophobia,* and *gynephobia.* We have already (pp. 334–335) considered how these normal and abnormal fears originate. Here we are more interested in how to eliminate them.

There are several ways to eliminate fear, some of which are much more successful than others. Among these are: (1) teaching skills which enable the individual to meet the situation effectively whenever it arises; (2) providing opportunities to become more familiar with the feared object or situation; (3) having the person witness others who show no fear in the feared situation; and (4) direct conditioning. Some of these methods are more effective in certain types of situation than in others.

Skills. Where the individual fears a bully, for example, the most effective method is perhaps to teach him boxing, wrestling, jujitsu, or other skills which will enable him to take care of himself when mistreated. This method applies to many situations, even including battle. When troops are taught to master situations met in battle, their fear tends to decrease. Preparation of American troops involves large-scale maneuvers carried out under conditions which as closely as possible simulate actual warfare. Soldiers who go through such situations many times, and learn how to meet all sorts of emergencies, enter actual conflict with greatly reduced fear. When one knows what to do, and has confidence in his ability to do it, he is not likely to be terror-stricken.[22]

Familiarity. A child who was afraid of rabbits lost his fear after a rabbit had for some time been in the vicinity. He had been given the opportunity to observe that it would do him no harm. Another child was afraid of frogs. When he wanted to play with a crayon, it was placed near a frog. The child ran over and picked up the crayon, apparently being for the moment unaware of the frog's presence. Later he said, "I ran over there and got it (the crayon). He (the frog) didn't bite me. Tomorrow I'll put it in a box and take it home."[23] We see in everyday life many examples of the effectiveness of familiarity with feared situations in reducing fear. Take, for example, the medical student who starts to dissect his first cadaver. Quite frequently, he approaches the task with thumping heart, trembling fingers, sweating palms, and marked gastrointestinal upset. After a week or two, it is not uncommon to see him eating a sandwich while prodding away quite nonchalantly at the corpse. Moving pictures often portray similar loss of fear in telephone linemen, paratroopers, pilots, and others, as they become more familiar with their jobs. Part of the adaptation in these instances is doubtless due to increased skill in meeting the situations involved.

The example of others. Children often lose their fear of particular objects, as a dog or rabbit, when they see that other children are not afraid. It sometimes happens, however, that the children to be imitated acquire fear from the one who is supposed to imitate them. For example, it was arranged to have a child who had no fear of rabbits play with them in the presence of a child who was afraid, the idea being, of course, to have the second child lose his fear. What happened, however, was that when the second

child cried, the first one became afraid.

Direct conditioning. The method of direct conditioning is fundamentally like that used in conditioning fears (pp. 334–335). Just as one may attach fear to a previously neutral object by presenting it with a fear-provoking one, the fear may be detached by presenting the fear-provoking object with one which characteristically elicits favorable reactions — an object, in other words, which has a strong positive valence. Thus, a child who feared rabbits lost his fear when a rabbit was associated with feeding. The rabbit was first presented at a distance. Then, in successive feeding periods, it was gradually moved closer to the child. This method must, of course, be used with great care. The feeding behavior, for example, might itself be disturbed were the child suddenly confronted with a rabbit.

Worry

Most of us recognize the undesirability of worry, even if we have not heard about its alleged role in the natural history of gastric disorder, but we continue to worry. Practically all that the psychologist can say about elimination of worry is in the nature of common sense, unsupported by experimental investigations.

It is, of course, obvious that worry over things beyond our control or over mistakes which cannot be corrected is completely useless. It neither does the worrier nor anyone else any good. Nevertheless, most of us continue to worry about such things. Worry about tasks and problems that are put off from day to day is also useless. The obvious suggestion is to face problems realistically, solve them to the best of our ability, and then forget them. In other words, the best way to cease worrying about that assignment is to do it. The best way to cease worrying about the difficult decision is to make it as soon as possible — perhaps utilizing Benjamin Franklin's method (p. 310) of balancing the pros and cons on one of the alternatives. The best thing to do about those fears of disease is to get a good physical examination — which many worriers about health avoid for fear of what they might find out.

A university professor in his 'forties had poor health habits, as a result of which he often had severe attacks of indigestion. Instead of correcting his living conditions and seeing a doctor to find out what was really wrong with him, he began to think of the possibility that his disorder was really stomach cancer. The more he thought about it, the more he was convinced that his diagnosis was correct. He finally had a physical exam, but the assurance of the physician that he did not have cancer was interpreted as the doctor's hesitation to tell him the worst. He finally shot himself, convinced that he would eventually die of cancer anyhow. A physical examination years earlier would have put his fears at rest before they had assumed such convincing proportions.

Worries of college students often concern sexual problems. A "hush-hush" attitude about sexual functions is partially responsible. Students are often worried about autoerotic practices. Such worry is intensified by the mistaken notion that their problems are peculiar. Actually, they are almost universal. Many persons are relieved immediately when they find out that they are not nearly so peculiar as imagined. Parents, by being frank with their children about sexual functions and by seeing that sources of needed information are available, could remove much of the worry related to sexual adjustment.[24]

Some reactions to danger

It is obvious that the best thing to do when confronted with a dangerous situation is to tackle it as one would tackle any other problem of adjustment — namely, by thinking of or actually trying this and that pos-

sible solution or means of escape. Some individuals are incapable of action in such situations. Others, because of training that has equipped them to handle such emergencies, react appropriately and with little emotion. The hunter who is sure of his gun and his aim does not fear the approaching lion. It is interesting to note, however, that many individuals who are neither transfixed in a dangerous situation nor ready with the appropriate response go through an extremely rapid implicit trial-and-error process. An aviator whose rudder stuck during a tailspin, and who fell four thousand feet before he regained control, reports the rapid review of possible solutions which occurred to him before he was successful in freeing the rudder.[25] Similar experiences are reported by an individual suddenly confronted with the task of saving a small child from death in a fireside accident.[26]

Individuals frequently meet a dangerous situation with little or no emotional upset, and then afterward "go to pieces." So long as one can handle a situation effectively, there is no cause to become emotionally upset. Moreover, preoccupation with the task in hand turns attention away from its dangerous aspects. The emotional response which often follows escape may result from thoughts of how dangerous the situation really was and what might have happened. Sometimes, too, the situation has arisen and gone before one has time to do anything but react reflexly. For example, you may be walking across the street when you hear screeching brakes. You jump, just in time, out of the path of an automobile. You then realize what has happened and perhaps think of how you would look in a box covered with flowers. The situation now, for the first time, becomes emotion-provoking.

A rapid survey of previous experience sometimes occurs when a person is threatened with impending death.[27] Individuals rescued from drowning often report such experiences. They have been reported by persons suddenly saved from a firing squad or from the electric chair. The flyer mentioned above reported that he relived more events of his life than he can well enumerate while falling from fifty-five hundred to fifteen hundred feet with his rudder stuck. He recalled events starting with the learning of his ABC's and covering various episodes up to the time, a year earlier, when he joined the services. A similarly rapid association of ideas sometimes occurs in the delirium which may follow rescue from dangerous situations, especially those involving prolonged exposure to the elements. Why this rapid mental survey occurs is not known.

CULTIVATING EMOTIONAL MATURITY

After all that we have said about eliminating or controlling "undesirable" emotional reactions, some attention should perhaps be given to the positive problem — that of cultivating such obviously desirable emotions as aesthetic enjoyment, happiness, affection, and sympathy for the rights and feelings of others. The need to develop desirable and to suppress or control undesirable emotions is well expressed in the concept of *emotional maturity*. The author of a well-known test of this trait has defined it as the "capacity for happy, full and effective living, which consists essentially in a loosening and slipping away of attitudes and interests which are tolerable in children but fatal in adults; these attitudes appear to consist in an overpreoccupation with the self and its satisfactions, a too great absorption of the field of attention with the ego."[28]

Much, in the direction of developing emotional maturity, can be done by way of example. Emotionally, children are very often like their parents. We have already called attention to the fact that they tend to fear what the mother fears. Children often learn to get enjoyment out of the things that their parents enjoy, to sympathize with that with which their parents sympathize, and so on.

Since the child is emotionally so much like his parents, one aspect of our problem is to produce emotionally mature parents. Mental health clinics for parents, as well as other forms of parent education, may do much to correct undesirable emotionality in parents. The wide-spread popularity of books like Overstreet's *The Mature Mind* * indicates that many people desire to improve their status as individuals and parents.

Literature, moving pictures, the radio, and television are also factors in emotional education, for children and others. We should accordingly take reasonable care that what is presented to children through these media is conducive to development of desirable rather than undesirable impulses. Religious education may do a great deal to inculcate a responsible and sympathetic attitude toward others. The cultivation of worth-while interests and hobbies, as well as the selection of a vocation in keeping with one's aptitudes (Chapter 23), are conducive to personal happiness. Selection of a suitable marriage partner is obviously an important factor in personal happiness as well as in the emotional development of one's children.†

There is of course no set formula for developing a desirable emotional life. It is much easier to tell people what to do to avoid development of or to eliminate some specific fear than it is to tell them how to achieve happiness.

SUMMARY

Feelings aroused by aspects of the environment are often indicated through preferences. Psychologists have used three procedures to study preferences. These are: (1) arranging items in rank order; (2) rating items on an arbitrary scale; and (3) paired comparison of items. Color, tonal, and other preferences are to a large degree determined by previous experience, both cultural and individual. However, physiological needs play a part in determining certain preferences. Intensity is also a factor, especially in the fields of taste and smell. When aesthetic appreciation is involved, the prestige of the artist, composer, writer, or performer tends to influence evaluation.

The study of annoyances has shown that human beings are annoyed by many things, most of which relate to other people and the things they do. Knowing the common forms of annoyance gives us improved opportunities for reducing human friction.

Generally speaking, our ability to judge what emotion is being expressed in terms of its facial, gestural, or vocal expressions alone is not accurate. Certain spontaneously aroused expressions have been judged with a high degree of agreement, but such agreement is rare. Even when it does occur, we cannot be sure that the judgments are correct unless the subject reports what emotion was actually experienced. It sometimes happens that many judge a certain emotion to be present, in terms of the face alone, and make a quite different judgment when the posture and general situation are observed. This fact, in itself, shows that agreement does not necessarily indicate a correct judgment.

Research with moving and still reproductions of facial expressions indicates that, on the average, the eyes and the mouth serve equally well as bases for judgment. Nevertheless, some expressions are judged more accurately in terms of the eyes and others

* Overstreet, H. A., *The Mature Mind.* New York: Norton, 1949.

† What we have reference to, primarily, are the social factors in marriage, but emotional development is also influenced by heredity, a further parental contribution.

more accurately in terms of the mouth. The face as a whole usually provides a better basis for judgment than either the upper or lower half alone.

The "lie-detector" does not detect lying, except indirectly. It measures emotional reactions elicited by questions relating to a crime. When the blood pressure, or breathing, or electrical resistance of the accused changes more in response to questions relating to the crime than for irrelevant questions, then he is assumed to be the culprit. The innocent person who knew nothing of the crime would be expected to have no different reaction to key questions from his reaction to control questions. It is the question, and what significance the subject gets from it, that determines whether or not an emotional reaction will occur. Whether he answers "yes" or "no" — lies or tells the truth — is irrelevant, except that an affirmative answer makes application of the "lie-detector" superfluous. Verbal and physiological reactions to words are also used to detect emotional complexes, especially in the fields of clinical psychology and psychiatry.

There is growing recognition of the fact that prolonged emotional upsets may contribute to, or even produce, organic disease. Case studies, and experiments on a man whose stomach was exposed for direct observation, suggest strongly that prolonged worry or anxiety can produce peptic ulcers. The participation of psychological, and especially emotional, processes in disease is now so well recognized that a special field known as psychosomatic medicine has arisen.

The most effective means of insuring control of emotional behavior is education of children in such control. Adults who lack emotional control may acquire it, but prolonged re-education is usually required. There is no rule-of-thumb method for the most effective control of anger in children. However, methods commonly in use have their strong and weak points. There are several ways in which fear may be eliminated in children. Which one will be most effective depends upon the individual concerned and the situations involved. Many adult fears go back to inadequate sex education in childhood. Frankness about sexual functions and about the effects of common sex habits would do much to remove worry based upon fear of physical and mental disease. The best way to meet situations which worry us is to make a realistic frontal attack — discover for certain whether our expectations and fears are warranted; force a decision when we are worried by conflicting alternatives; do the tasks which we are obligated to do, so that we need no longer worry about them; and refuse to dwell upon unpleasant things beyond our control.

Quite frequently, the dangerous situation passes before an emotional upset occurs. This is, at times, because one's thinking of what might have happened — rather than what was happening at the time — provides the emotion-provoking stimulation. Dangerous situations often provoke an extremely rapid trial-and-error reaction which may be implicit, explicit, or both. When one's own life is imminently threatened, there is often a rapid survey of past experience.

The attainment of emotional maturity depends upon many influences brought to bear upon the growing child, the most important of which are found in the home and community.

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Part Seven

Knowing Our World

Our receptors are the "gateways to knowledge." The blind and deaf live in a world represented only by such experiences as result from felt vibrations, contacts on the skin, temperature changes, odors and smells. A person blind from birth has no visual images. He has no imagery such as characterizes most of our dreams. Likewise, the congenitally deaf have no auditory imagery. There are, of course, several ways in which aspects of the world of light can be conveyed to the blind and aspects of the world of sound to the deaf, but the representations provided are neither visual nor auditory, and they are poor substitutes for the real thing. Imagine "seeing" a face by running your fingers over it or "hearing" a symphony by placing your fingers on the loud-speaker of your radio.

Quite obviously, nobody can observe any experience except his own. This fact, as we pointed out earlier, has raised the issue of whether one can really have a science of experience. Science does at times deal with things which cannot be observed directly, but it does so only by inference. Take, for example, electricity, atomic fission, and genes. Such inferences are based upon objective evidence and are tested by the outcomes of experiments and other observations. Discussions of experience must also be inferential. The objective basis of the inferences is what people do and say. Some psychologists prefer to confine their discussion to the observable facts while others proceed to draw inferences concerning experience.

If a person jumps away from a needle or an electric shock, for example, one may infer that the experience is painful. But he is not forced to make this inference. The objective fact is that a reaction of withdrawal occurred. But suppose the individual said that he felt pain. Added to the other objective fact would be the verbal report "pain." Indeed the descriptions which others give us of what they see, hear, taste, smell and feel often agree closely with the descriptions which we ourselves would give if similarly stimulated. Although we cannot observe their experience — and we do not need to infer its presence

— we cannot escape the fact that their words have obvious relevance to aspects of our own experience. I can ask you the color of the sunset which we are both viewing, and your response "red" seems quite adequate to describe the color of the sunset as I see it. Had you asked me, I would also have said "red." There is, of course, no proof that what you and I call "red" represents the same experience. All we know is that under the circumstances "red" is sufficient for purposes of communication. Such terms are also sufficient for scientific purposes. We do not need to infer anything beyond the linguistic facts, but for purposes of communication it is more meaningful to use everyday language, based as it is upon aspects of personal experience and inferences concerning the experiences of others. Thus I might say that we are aware of the red sunset, the odor of flowers, and the pain in our tooth or I might say that we act "as if" we are aware of such things. Only the most circumspect scientist would insist upon the latter terminology.

Reactions against the psychology of experience were instigated by the attempt of some psychologists to overemphasize or to infer too much from verbal reports. They sought detailed descriptions of experiences and from these descriptions, attempted to infer the "ingredients" of which experience is composed. They inferred, for example, that complex experiences may be broken down into sensations, images and feelings somewhat in the analogy of a house being separated into bricks. Many of their inferences were disputed by other students of experience and it became clear that verification, a necessary aspect of science, could not be achieved, or could be achieved only with the greatest difficulty.

The following chapters, while they use the "language of experience" that is part of our common social heritage, are still within the objective frame of reference to which the rest of the discussion has adhered. All of the topics discussed are responses of the organism — not of some disembodied mind — and they could be presented, without inferences about experience, in strictly behavioral terms. One would then discuss discriminative responses (verbal and non-verbal) instead of what is seen, heard, and so forth. Such a discussion, though strictly correct, would of necessity be so circumlocutious that few students would make the effort to understand it.

The process of attending is given prior consideration (Chapter 16) because, unless we attend to them, aspects of our world fail to influence our reactions. Perceiving (Chapter 17) is discussed before receptor processes (vision, hearing, and the other senses) because, while it involves these processes, it includes much that is independent of a specific receptor process. In other words, visual perceiving, auditory perceiving, and other specific varieties of perceptual process, have much in common. Chapters 18, 19, and 20, dealing with vision, hearing, and the simpler senses, emphasize the contribution of receptors and related neural processes to perception. They include discussions of visual, auditory, and tactual space perception.

16 ATTENDING

Set and Attending • Some Aspects of Attending: Receptor adjustments; postural adjustment; muscle tension; central nervous adjustments; attending and clearness of perception • Fluctuations of Attention • Varieties of Attending • Determiners of Attention: External determiners; internal determiners • Attending and Perceiving • Summary

In everyday language we speak of giving this or that situation our attention, of concentrating attention on something, and of shifting attention from one thing to another. This manner of speaking often leads to the naïve assumption that attention is a faculty or power which we can turn on or off at will, or something which we lend to this or that situation. All of us use the term *attention,* and use it often. There is no good reason why we should cease. It should be realized, however, that we are referring to an act, a process, a function — not to a power or faculty. Thus, it is more correct to speak of attending than of attention, although this usage may at times be more roundabout.

Attending, from whatever angle we consider it, is in the last analysis a motivational process. You do not respond indiscriminately to every aspect of your environment, and you do not make every response that could be made in a situation. You react selectively. You respond in terms of your interests and attitudes. Sometimes, moreover, you attend "voluntarily" and sometimes "involuntarily." Interests, attitudes, and voluntary action are topics considered within the framework of motivation. Thus, attending could also be considered from the standpoint of motivation. One introductory text deals with the process primarily from this standpoint.[1]

SET AND ATTENDING

We are already familiar with set as a determining or directing factor in association and thought. It is relevant in the present context because attending may be considered a form of set. Here we use the concept of set in much the same sense as formerly, but with particular reference to receptor, muscular, or neural adjustments which contribute to, or interfere with, perceptual or motor responses. We say that the person with his eyes focused upon something is set to see it. This is an example of receptor set. It is also a muscular set, for eye muscles turn the eyes toward and focus them upon the object. We say, too, that the doctor who hears the telephone during the night, but fails to hear the baby cry, is set to hear the telephone. His wife perhaps fails to hear the telephone, but hears the baby. We say that she is set to hear the baby. This is an example of so-called mental set. The batter with his bat in position to hit the ball has a receptor set, a postural set, and probably a mental set as well.

Some sets not only fail to contribute to, but actually interfere with, perception. You may be so preoccupied with what you are writing that you fail to hear what is being said on a near-by radio. You are set for writing, but not for hearing the radio. Your

set for writing is synonymous with attending to writing, but its significance is broader than this, for it actually interferes with hearing the radio. Likewise, the ventriloquist, through the antics which he makes his doll perform, gets us set to notice the doll and its mouth movements. This attentive set is so disarming that we not only seem to hear words issuing from the doll's mouth, but also fail to notice the ventriloquist's lip movements, which, while quite abbreviated, are observable if we attend to them. Postural sets likewise facilitate some responses and interfere with others. When the boxer feints, his opponent assumes what appears to be an appropriate posture to ward off the blow, but the blow comes from a direction for which he is not prepared, hence his set in response to the feints puts him at a disadvantage. He would have been better off to parry the blow from a neutral position than from the one assumed in response to the feint.

It should be apparent, therefore, that sets may aid or hinder perception and other forms of response. Attending is set looked at from the standpoint of its contribution to the process of perceiving or acting. In other words, we may be said to attend to some situation when our set prepares us for perception of, or makes us more ready to react to, that situation.

From the standpoint of perception, attending has aptly been called a "preperceptive attitude" — a "reaction of expectancy and exploration,"[2] or "an anticipatory perceptual adjustment."[3] This readiness to be stimulated, or to perceive, is the aspect of attending which interests us most in the present chapter.

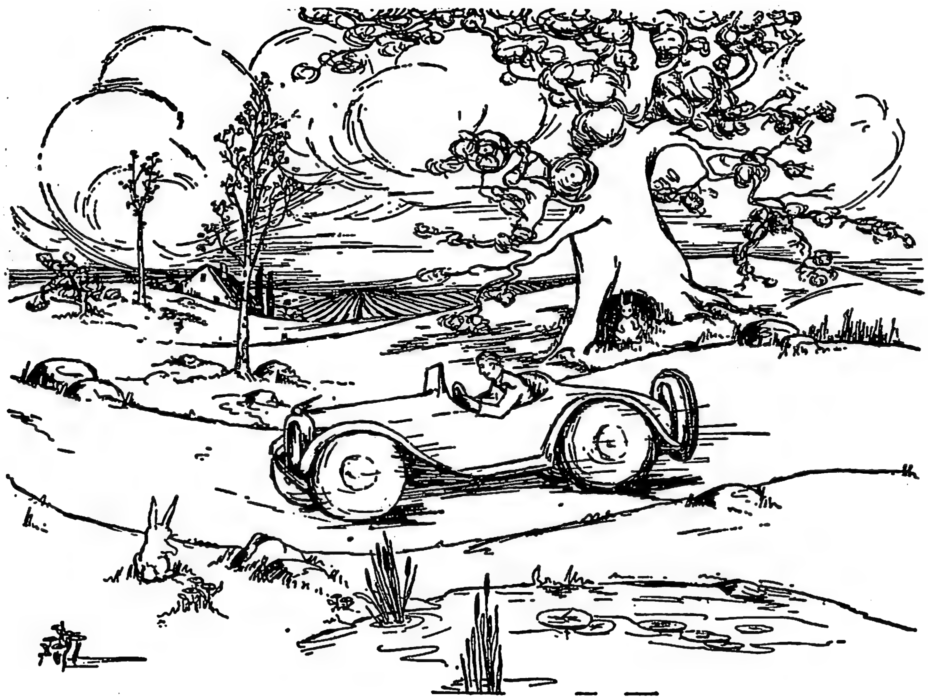
SOME ASPECTS OF ATTENDING

The act of attending may be considered from at least five different standpoints. First, it involves *receptor adjustment.* Second, it involves general *postural adjustment.* Third, it is characterized by *muscle tensions* and related feelings of effort. Fourth, it involves some sort of *adjustment in the central nervous system,* perhaps even apart from, or in addition to, neural adjustments incident to the receptor and motor processes. Finally, it is characterized by an *increased clearness,* a bringing-out of detail, in whatever is attended to. Some of these aspects of attending are readily observable, either in ourselves or in others.

Look at the puzzle picture in Figure 180 and search for the hidden motorcycle policeman. Note, before you start, that no such person is clearly, or perhaps in any way, apparent. While carrying on the search, which is obviously a process of attending, you adjust your head and eyes, there is a change in general body posture, muscle tensions are involved, and various changes take place within your nervous system. You are perhaps not aware of many such changes. When you finally discover the policeman, you will observe that he stands out from everything else. He will probably stand out so obviously that you cannot fail to see him.

Many of the adjustments involved in attending can best be observed in someone else. Ask somebody who has not already seen Figure 180 to search for the policeman. Note the eyes scanning the picture; note the generally alert posture; note changes in posture, or in the position of the book, so that the picture may be observed from various angles. Observe whether the muscles of the face are more tightly drawn as unsuccessful exploration continues. Quite frequently there are emotional reactions during such a search. The subject may be frustrated by inability to discover what he is looking for, and may become exasperated. On the other hand, he may become generally relaxed after discovery.

Similar receptor, postural, and emotional reactions are often observed in students when the teacher is trying to "put across" some idea not easy to grasp.



180

A Puzzle Picture

Can you see the motorcycle policeman? Once you have seen him, his presence is obvious. If you see him right off, try this on someone else. (From Franz, S. I., and K. Gordon, Psychology. *New York: McGraw-Hill, 1933, p. 405.)*

Receptor adjustments

As already suggested, gross receptor adjustments in visual attending are readily observable. The head and eyes turn toward the object to be observed, and there is either a continued fixation or a scanning process. Rapidly changing adjustments of head and eyes may be seen in the observers of a tennis match as the ball goes from one player to another.

Devices for photographing eye movements and the duration of fixations are often used to determine the "attention value" of different parts of a page and of different aspects of an advertisement. Such a device is illustrated in Figure 181. It is assumed that those portions which attract the eyes most often and for the longest continued fixation periods have the highest attention value. Eye movements and successive fixations involved in a woman's scanning of a man and the per cent of time involved in surveying different male features are illustrated in Figure 182. These results were obtained with the camera shown in Figure 181. Other ocular adjustments are the accommodation of the iris muscle and lens and the convergence of the eyes (pp. 430, 437).

When the dog "pricks its ears," we have just as obvious a receptor adjustment as that of turning the head and eyes. Some animals not only erect their ears, but also turn them in directions conducive to better reception of sound waves. The hard of hearing in former days moved their ear trumpets in a somewhat similar fashion, and for the same purpose. We cannot move our ears, but we

181

A Bidimensional Eye-Movement Camera

This camera, invented and developed by Dr. Herman F. Brandt, of the Visual Research Laboratories of Drake University, photographs the duration, location, and sequence of every eye fixation, as well as the distance and direction of every eye movement. By means of this instrument the relative attention value of such physical variables as color, size, isolation, and position may be ascertained. For further information see Brandt, H. F., "The Psychology of Seeing," Philosophical Library, 1945. (Used by permission of Doctor Brandt and Look.)

do move our heads to facilitate reception. This is especially evident in the person who has only one good ear. He turns his head to bring it in the direction of the sound waves; he may even cup his hand behind it. A finer receptor adjustment associated with hearing involves a muscle of the middle ear (the *tensor tympani*). This muscle produces a change in the tension of the eardrum to adjust it for sounds with different intensities. The adjustment apparently protects the ear from being injured by low tones of great intensity.[4]

Changing the position of the nose and sniffing are obvious receptor adjustments. Touching a substance with the tip of the tongue and moving it around in the mouth so that it falls near the tip, back, or side are likewise receptor adjustments.

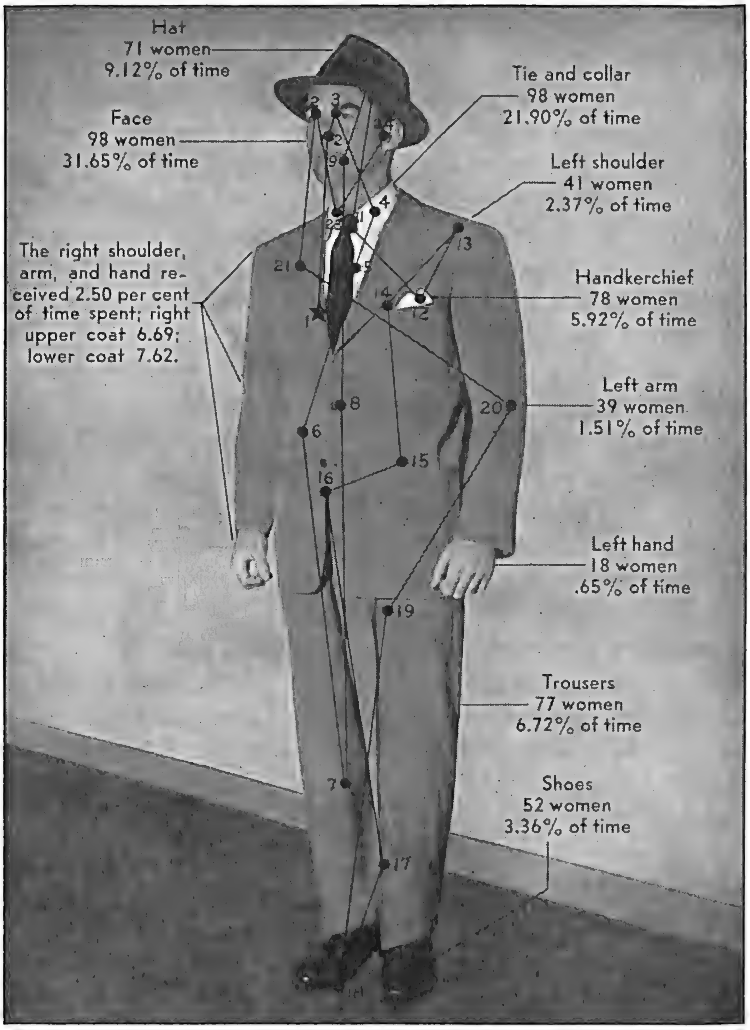
Postural adjustment

This form of adjustment is especially evident when one stoops, as in looking at something on the ground, when one crouches on the starting line, and when one strains for-

ward in his seat. Attentive postures may be continued for long periods without tiring the person, so long as what he is attending to is inherently interesting. The dog pointing and the cat with its paw in position to catch a mouse about to emerge from a hole are good examples of attentive posture. Consider, too, as a human example, the soldier standing at attention.

Muscle tension

This is involved in any postural adjustment, but it is at times more subtle than



182

Eye Movements of a Woman in Looking at a Man

The dots and lines on the man show successive fixations of one woman in visually attending to a man. She looked first at his chest; then her eyes swept up to his face, moved to his left eye, then down to his collar, etc. The percentages indicate time spent by 100 women in fixating each of the indicated parts of a man and his clothing. (Courtesy of the copyright owners, Marshall Field & Company, and Look. *The research was done by Doctor Herman F. Brandt of Drake University.)*

general observation would indicate. For example, when efforts are made to distract subjects working at (attending to) a task, the expected decrease in efficiency often fails to appear. But there is often clear evidence of increased attention to compensate for the distraction. Associated with this compensatory process is increased energy expenditure, some of which is attributable to heightened muscle tension.

Six subjects were given a task in which they were required to press appropriate keys as each of a series of letters was exposed. There were ten keys, somewhat comparable to the keys of a typewriter. These were numbered from 1 to 10. The letters exposed were L M N P S T V X Y Z. They were exposed upon red, yellow, or green backgrounds. As a letter appeared, the subject was required to look at it, note the color of the background, look at a code just below, translate the letter (in accordance with the code) to one of the first ten letters of the alphabet, then press the key whose number corresponded to the number of the letter of the alphabet. Pressure brought automatic exposure of a new letter. Unknown to the subjects, there was attached to each key a device through which the amount of pressure exerted could be determined. The aim of the experiment was to see whether the amount of pressure would change when attempts were made to distract the subject by introducing noise. The average pressure exerted under conditions of quiet was tested, both before and after noise had been introduced. This pressure under conditions of quiet was compared with the average pressure during noise. All six subjects exerted more pressure under noise conditions than under conditions of quiet. The average pressure exerted just before noise was introduced was 305 grams. Under noise conditions it rose to 438 grams. In a period of quiet which followed noise, the average pressure was 292 grams. The amount of work accomplished did not differ significantly under conditions of noise and quiet. Heightened attention to the task, with which the muscular exertion was associated, apparently compensated for the distracting influence of noise.[5]

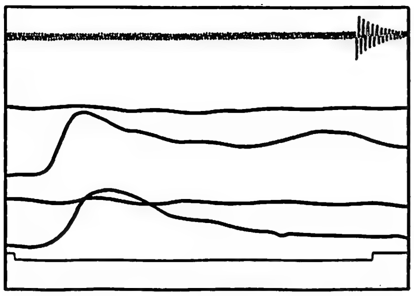
Another example of muscular tension during the act of attending comes from an experiment in which the thickening of each of four muscle groups was measured while (1) the subjects were listening for a click known to be barely audible, and (2) they were listening for a click known to be quite obviously audible.[6] Subjects were required to press a key as soon as the sound was heard. They attended more closely while expecting the weaker than while expecting the louder sound. Concomitant with this additional effort was a greater thickening of the muscles whose tension was recorded. Typical records are shown in Figure 183.

Muscle tensions are involved in the act of attending in yet another way. When one has been asked to attend to something, and especially when he has been asked to attend to a variety of specified details, he is likely to repeat the instructions, either aloud or silently. Even when he repeats them silently, his tongue, throat muscles, and perhaps other muscles of his body are thrown into action. Action currents generated in this way were discussed in the chapter on thinking.

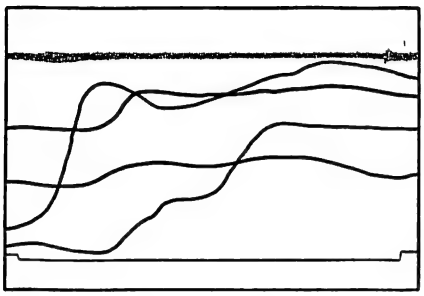
Central nervous adjustments

The adjustments so far considered are largely peripheral or surface phenomena. However, these adjustments necessarily involve the central neural mechanisms.

Every psychologist would admit that central mechanisms are involved in the act of attending. There is much controversy, however, concerning the possibility of a central adjustment independent of receptor and postural adjustments. There are two contrasting views on this issue. According to one of these, attending is merely a receptor



Stimulus strong



Stimulus weak

183 **Thickening of Muscles in Listening for a Weak Stimulus as Compared with Listening for an Intense Stimulus**

The record at the top was taken while the subject expected a loud click, and that below while he expected a weak one. At the top of each figure is a record of the subject's finger reaction as he heard the signal. Note that only two muscle groups, and these only weakly, thickened while the subject anticipated a strong stimulus. While he was anticipating the weak stimulus, however, all four muscle groups thickened, and one which thickened under the other condition now thickened to a greater extent. (After Freeman, G. L., "The Spread of Neuro-Muscular Activity During Mental Work." J. Gen. Psychol., *1931, vol. 5, p. 486.)*

and postural adjustment, the central nervous system exerting no independent control. According to the other view, the central nervous system, especially the cerebral cortex, sometimes plays an independent role in attending.

It would be easy to settle this issue if we could find some way of measuring specific central neural adjustments without at the same time involving receptor and postural changes. The problem is similar to that already confronted in the discussion of central and peripheral-central theories of thinking.

Hypnotic phenomena sometimes suggest centrally maintained sets either to attend or not to attend to stimulation. Thus, a hypnotized subject may be made apparently inattentive to painful stimulation, such as a burn, an electric shock, or a pin-prick. The subject is told that his skin is insensitive, whereupon presentation of the normally painful stimulus elicits no reaction. This suggests central inhibition. On the other hand, the suggestion that any stimulus, even a light touch, will be painful brings out a reaction simulating the reaction to painful stimulation. This suggests central facilitation.

Research on attending suggests, but fails to prove, the existence of a central control independent of peripheral adjustments.

In one study, human subjects, seated with one finger on a simple key, were instructed to lift the finger whenever a light or a sound appeared. If a light appeared, they were to lift the finger as quickly as possible. If a sound appeared, they were to make exactly the same response. Thus, the stimulus was either light or sound. Moreover, the same response was to be made to light or sound.

Subjects were sometimes told to expect a light, sometimes to expect a sound, but to react, whichever stimulus actually appeared. When light was expected, the reaction to light was faster than when sound was expected. Likewise, the reaction to sound was faster when sound was expected than when light was expected. Since exactly the same posture and response were required in each case, it was assumed that different expectations produced the differences in time of reaction. These expectations were assumed to be purely central in origin, involving some adjustment of the central nervous system.[7]

However, if one expects a sound, his head

may be held in a different position from that held if he expects light. Even if his head remains stationary, his *tensor tympani* may adjust the eardrum for sound reception. Likewise, his eyes may be set for the reception of light (but his ears not involved) when light rather than sound is expected. These receptor and related muscular and neural processes may account for a faster reaction when what is expected actually appears. There is thus no clear evidence that a purely central neural process was involved in the above experiments.[8]

In an attempt to answer such criticisms, several additional experiments were undertaken. Some of these support the central theory and others, while they do not support it, do not provide conclusive arguments against it.

In one of the experiments offering some support for the central theory, subjects responded to either an auditory or a tactile stimulus, the latter provided by a vibrator attached to the skin. At times during the experiment, there was an unexpected shift from auditory to tactual or from tactual to auditory stimulation. On such occasions, as in the first experiment mentioned above, the subjects reacted more slowly when they expected one form of stimulation and the other appeared. The crux of this situation is that the skin receptors have no known adjustment which prepares them for stimulation, hence it is claimed that (if a central factor were not involved) they should have been just as well prepared to mediate the response when a sound was expected as to mediate it when a vibration on the skin was expected.[9]

We cannot yet regard the issue of a purely central adjustment as settled. The last of the abovementioned experiments suggests that receptor adjustment is not essential in an act of attending, but it does not prove this point conclusively. One could argue that the subject's ear was set for sound and that immediately upon failure of the sound to appear, its relaxation retarded the motor response through interference of related neural activities with those involved in making the finger reaction. Such an interpretation may be far-fetched, especially since the difference in reaction times under the two conditions was sometimes as small as one twentieth of a second. Nevertheless, we cannot completely ignore such a possibility.

Thus, while central neural adjustments are intimately involved in attending, there is as yet no conclusive evidence that they are ever independent of receptor and postural adjustments.

Attending and clearness of perception

As we have already pointed out, attending to some aspect of the environment or to some bodily process is followed by a clearer perception than previously existed. Part of this increased clearness, this bringing-out of details, is due to receptor adjustment. While reading these words, you are only vaguely, if at all, aware of your surroundings. But suppose you now attend to a piece of furniture in front of or to the side of you. Its image may have been falling upon your eye while you were reading, but it either elicited no conscious reaction or, at best, only a vague perception. Now, if you fixate upon it, the lens of your eye adjusts so as to bring it into better focus on your retina. This makes it clear and its details distinct.

Although receptor adjustment plays a part in clarifying perception, it is not solely responsible. One may have a perfectly clear retinal image, yet — especially if he is preoccupied with his thoughts — fail to have a corresponding visual perception.

Postural adjustments and muscle tensions also fail to tell the whole story. The student in a classroom may be in a posture of rapt attention, but, when called upon by the teacher to recite on what has just been said, he may reveal that his thoughts have been

far away from the classroom.

Do such facts indicate that there is really some sort of central nervous adjustment independent of, or in addition to, the central neural adjustments incidental to receptor and postural changes? They strongly suggest, but do not prove, that such an adjustment exists. It is conceivable that there are more subtle receptor and postural aspects than we are able to observe under such circumstances. Although the student has his ear cocked and is straining forward in his seat as if listening intently to the teacher, this may be a pure affectation. We might find, if we were able to observe him closely enough, that this attitude actually differs from his attitude when really listening. Moreover, thought processes involve widespread activity of the central nervous system and, as mentioned earlier, muscle tensions in various parts of the body. These activities may account for lack of attention (or preoccupation), despite appropriate receptor and postural adjustments. In other words, they may inhibit neural processes which would ordinarily accompany attentive adjustments.

FLUCTUATIONS OF ATTENTION

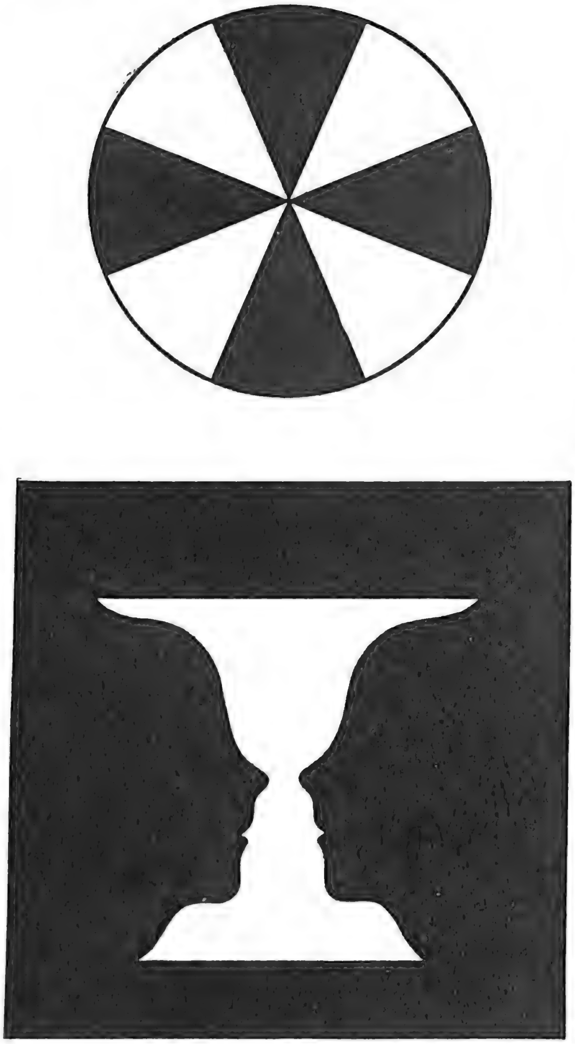
If you have somebody hold a watch at such a distance from your ear that you can barely hear it, you will notice that perception of its ticking appears and disappears. Likewise, if you fixate upon a small, almost invisible point, or upon a very dim star on a clear night, it will appear and disappear. Is this because you are in some way changing your receptor or postural adjustment? Or is it because your brain is undergoing some sort of fluctuation with which the fluctuation of attention (perception) corresponds?

In very general terms, these fluctuations are explained by supposing that the whole receptive apparatus, from sense organ to brain, must be functioning perfectly in order to perceive a very weak stimulus. Any momentary lapse in efficiency interrupts the sensation. Of the different parts of the receptive apparatus, the sensory nerve is least likely to fluctuate in efficiency. The locus of the fluctuations may be the sense organ or the brain, or both. One possible factor has been exploited by one investigator, and another by another.[10]

Research has disclosed quite convincingly that certain receptor aspects are not involved. For example, absence of the eardrum does not prevent auditory fluctuations and absence of the lens does not prevent visual fluctuations. Eye movements influence the frequency of visual fluctuations, but fluctuations continue to appear during fixation.

Other receptors and postural adjustments could be involved. Changes in retinal adaptation, in the occipital cortex, and even in respiratory and circulatory activities, have been found to affect the frequency of visual fluctuations, and they may be responsible for the fluctuation phenomenon.[11] There is the possibility, too, that slight changes in posture and in muscle tensions throughout the body enter into the total picture. Thus, there is no evidence that this phenomenon is due exclusively to central adjustments.

A somewhat related phenomenon to those just discussed is fluctuation of figure and ground in reversible configurations, like those illustrated in Figure 184. If you fixate the center, or any other part of either figure, you will note that now one aspect stands out, now the other. At one moment, for example, you see the black figures as though on a white background; the next moment you see the white figures as though on a black background. The frequency of such fluctuations can be influenced by trying to hold one as long as possible. The figure will change, despite your effort to hold it, but it will very likely change less often. Frequency of fluctuation in figures like the circular one is markedly influenced by the size, area, brightness, and color of the respective systems.[12]



184

Reversible Configurations

Observe that white can be either figure or ground.

There are several possible explanations of fluctuating figure-ground relations. Some psychologists stress the importance of receptor, postural, circulatory, and respiratory factors; others stress the independent contribution of central neural functions. The latter often attribute the fluctuations to what they call "brain dynamics."[13]

VARIETIES OF ATTENDING

If the dividing line is not too distinctly drawn, it is possible to classify three types or varieties of attending — namely, *involuntary*, *voluntary*, and *habitual*.

When stimuli or situations force themselves upon us, as it were, whether or not we are set for their reception, attending is said to be *involuntary*. Thus a pistol shot, an intense electric shock, a sudden intense flash of light, a blow, and painful stimulation of any kind are perceived involuntarily; one might say "reflexly."

Whenever we intentionally look or listen, attending is referred to as *voluntary*. Someone may say, "Look at this," or, "Do you hear that?" and you may respond accordingly. You may strive to attend to an uninteresting lecture, knowing that if you fail to attend, your grade may suffer. You may go into town with the intention of buying a camera and, as you walk along the street, pay particular attention to camera displays in the store windows. These are all examples of voluntary attending.

When attending is difficult, as in listening to a lengthy and colorless discourse by a friend, it is often said that continued attention demands "will power." There is no doubt that the feeling that one should listen, and the temptation to do, or think of, something more interesting, produce a conflict situation. Attempts to resolve the conflict bring about a feeling that great effort is being expended. This problem, it will be recalled, was considered more fully in discussions of will power and initiation of action (pp. 319–322).

Each of us is more or less permanently set for reception of certain stimuli. Think, for example, of the doctor set to hear the telephone and his wife set to hear the baby. Think of the male's readiness to notice a beautiful girl and the female's readiness to notice a handsome male. Think of our periodically occurring interest in food and drink.

Think of our readiness to perceive good in the actions of our friend and evil in the actions of our enemy. Think of the naturalist's observation of plants and bugs which we fail to notice. Think of the attitude of alertness which characterizes a class as soon as such topics as sex, hypnotism, or mental telepathy are mentioned by the instructor. These are examples of so-called *habitual* attending or of habitual sets. Most of our acts of attending are continuing rather than abruptly assumed sets, and they are sets of which we are frequently unaware. These continuing sets stem from our motives. They are related to drives, interests, attitudes, prejudices, and aspirations.

DETERMINERS OF ATTENTION

The preceding discussion has suggested that attending is related to external stimuli and to conditions within the individual. These are often called the determiners of attention.

There has been a large volume of research on the attention-getting value of different aspects of external stimulation. The findings, as one can well guess, have proved extremely valuable in the field of advertising. An advertiser's problem is to sell his product, but before he can induce you to buy it, he must call your attention to it and also to the reasons for preferring it to other products. As you turn the pages of a magazine, scan the newspaper, or listen to your radio, there are many things more interesting than observing what an advertiser has to say about his wares. Hence, he must literally force you to attend. Any advertisement which produced involuntary attention, and then caused you to hold your attentive set, would be most effective. Successful advertisers use external stimuli which will "catch your eye" or "get your ear," and at the same time stimuli which will, as it were, tap your motives.[14]

External determiners

Among the important external determiners of attention are the nature, location, and novelty of the stimulating conditions.

By the nature of stimulating conditions we refer to such things as whether a picture is that of a woman, an animal, or a product to be sold. By the nature of auditory stimulation we refer to such things as a narration, singing, or orchestral music. It has been shown, among other things, that pictures attract attention more readily than words; that a picture with human beings in it tends to attract attention more than a picture of inanimate objects alone; and that some rhyming auditory passage attracts attention better than the same passage presented as a narrative.

The best location of a visual stimulus from the standpoint of attention-getting is directly in front of the eyes. Where this is not possible, there are still certain positions better than others. Research in advertising has determined the attention value of various positions, not only within a magazine, but also on a given page. This research has utilized eye-cameras like those already mentioned.

Intensity is exemplified by a brilliantly lighted sign or the blaring of a loud-speaker. As you read this **sentence,** you can hardly escape noticing the word printed in black type. You probably noticed it as soon as you turned to this page. Here we have not only intensity, but contrast. The black letters, because of their relative intensity, stand out from surroundings. Intense odors, tastes, pressures, and pains, especially when they represent a sudden change from previous stimulation, also elicit attention.

The size of a stimulus is of obvious importance, but again contrast is an important aspect. If all of the LETTERS on this page were printed in capitals, the capitalized word in this sentence would have no greater attention-getting value than any other word;

if all were printed in small type, the word with small type would have no advantage. Generally speaking, a large advertisement will get more attention than a small one, especially when the latter is surrounded by other material. But an extremely small advertisement in the center of a page that is otherwise blank is a strong determiner of attention.

We have already observed (p. 362) that certain colors and color combinations are more agreeable than others, and that advertisers have made use of this fact. Reds and blues play a large part in color displays because of their agreeableness. But here again, contrast is important. If one of these words were printed in any color but black, you would notice it as soon as you turned to this page. It would not matter what the color happened to be. Color advertising derives some of its attention-getting value not so much from the colors or color combinations used as from the fact that, being colored, it stands out from the black and white which characterizes most of the other material in the magazine.

Other things being equal, a moving object is more attention-demanding than a stationary one. This is true for animals. Many an animal is safe from others so long as it keeps still, but as soon as it moves, it is pounced upon. The large neon signs typical of Broadway illustrate the value of moving stimuli. These utilize a phenomenon to be considered in the next chapter.

Repetition is a factor of great importance in drawing attention to some aspect of our environment. When a stimulus is repeated several times, we may eventually notice it, although we failed to do so at first. Despite the value of repetition in calling attention to a stimulus, continued repetition beyond a certain point may bring diminishing returns. We may eventually become so accustomed to the situation that it ceases to be noticed. Advertisers get around this by introducing change, and especially novelty.

Most of us attend to anything that is novel. Sounds, smells, and tastes to which we are accustomed may go unnoticed, where a strange sound, smell, or taste is immediately noticed. We see examples of this principle in the futuristic rocket ships, planes, trains, and busses used to illustrate much present-day advertising. Strange animals and unusual dresses or furnishings attract attention because of their novelty. Use of novelty to attract attention is but another example of contrast. Anything that is novel derives this property through its contrast with what is customary.

Internal determiners

External factors are potent to the degree that they tap, as it were, our continuing sets, the internal determiners, which were elsewhere referred to in the discussion of habits of attention. These determiners, as we have already suggested, stem from motives. If the individual is motivated by hunger, he is much more likely to notice the smell of cooking food or to see the picture of steak on a magazine page than if he has just had a good meal. The sexually deprived male is much more likely to notice females than is the sexually satiated one. Any advertisement involving a "leg show" is almost sure to get male attention. The man who is forced to play a submissive role, but would like to assume a dominant one, is prone to notice the physical-culture advertising. The person deprived of desired recognition notices the advertising headed, "They listened in amazement when I began to play." The movie fan is more likely to attend to an advertisement with the picture of a movie star than one with a picture of some other person. A student is especially attentive to any statement prefaced by such remarks as, "Don't fail to get this!" or, more pointedly, "I shall expect you to know this in the examination." Instructions such as "Find the hidden man" likewise produce a continuing

set which, when it has once been engendered, is an internal determiner of attention.

ATTENDING AND PERCEIVING

Attending and perceiving are in some respects indistinguishable. What one psychologist discusses as fluctuation of attention, another discusses as fluctuation of perception. One psychologist asks, "How many things can we attend to at once?" while another asks, "How many things can we perceive at once?" Likewise, it would make little difference whether we referred to "involuntary attention" or to "involuntary perception." In all such cases the end product is the same, whether considered from the aspect of attending or that of perceiving. Similarly, the determiners of attention described above might have been discussed as determiners of perception.

In certain other instances, the two processes are clearly distinguishable. In the first place, with the possible exception of so-called involuntary attention, attending clearly precedes perception. This is why attending has been referred to as a *pre-perceptive* or anticipatory attitude. In the second place, attending does not guarantee that perception will follow. One may listen for the expected call that fails to come. He may look, but fail to see. In the third place, attending does not in itself determine the organization or meaning of conscious experience. The same situation may be perceived differently by all who attend to it. It may be meaningful for all, but have a somewhat different meaning for each.

Different anticipatory adjustments (especially what we call *mental sets*) not only prepare us for perception, but also have a selective function. Their influence upon what we perceive will be considered in the following chapter. It is clear, however, that having an anticipatory set and perceiving something relevant to it are to some degree different processes. The perception itself depends, not only upon the mental set, but also upon the forms of stimulation, the receptor functions, and the neural functions which follow assumption of this set.

SUMMARY

Attention is not a power — it is an act, a process, or a function. Thus, it is more correct, although often more cumbersome, to speak of attending than of attention. Attending has many ramifications, being related to motor activity as well as perception and also to learning, the thought processes, and motivation. In the present chapter we have focused especially upon attending as an aspect of perception. From this angle it may be defined as an anticipatory perceptual adjustment or as a readiness to perceive.

The act of attending is characterized by receptor adjustment, postural adjustment, muscle tension, and central neural adjustments. From the standpoint of perception, these adjustments bring an increased clarity of detail.

There has been much interest in central neural aspects of attending. It is generally recognized that central neural processes are a necessary part of receptor and postural adjustments, but controversy has hinged upon the question of a central control independent of, or in addition to, such peripheral adjustments. Some recent research suggests the possibility of an independent central control, but it does not provide conclusive evidence of such control.

When stimulation is weak (as in the case of a barely audible sound) or ambiguous (as in the case of reversible configurations), the phenomena known as fluctuations of attention occur. There is evidence that such fluctuations, while influenced by receptor adjustments, and respiratory and circulatory

changes, stem partially from some independent central neural adjustment. Again the evidence suggests, but does not prove, existence of an independent central control.

Three varieties of attending may be distinguished. These are involuntary attending (such as is produced by an unexpected shot), voluntary attending (as in attending at somebody's request or from a sense of duty), and habitual attending (exemplified by continuing sets or attitudes like the mother's readiness to hear her baby's cry). Voluntary and habitual attending are motivational activities, being related to needs, interests, and attitudes.

Determiners of attention may be differentiated into two broad but somewhat related groups — namely, external and internal determiners. Typical of external determiners are the nature, location, intensity, size, color, movement, repetition, and novelty of stimulating conditions. A factor which runs through many of these is that of contrast. In other words, to the degree that they contrast with their surroundings or with what is customary, stimulating circumstances gain in attention-getting value. Internal determiners are related to motivation. In short, we are most likely to attend to aspects of our needs, desires, and interests. Determiners of attention are of special interest to advertisers, one of whose chief problems is that of attracting attention to their products.

Attending and perceiving, although at times indistinguishable, must be regarded as separate processes. This conclusion is based upon the observation that attending usually precedes perception, that it sometimes occurs without being followed by perception, and that it does not necessarily determine the meaning of what is perceived.

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17 PERCEIVING

Analysis of Perceiving: Receptor processes; symbolic processes; affective processes; analysis of perceiving summarized • Why We Perceive What We Perceive • Some Examples of Primitive Organization: Illusions; perceptual constancy; relational discrimination • Context • Past Experience in Perceiving • Set in Perceiving • Reduced Cues • Perceiving Differences • Summary

PERCEIVING IS A PROCESS comparable with discriminating, differentiating, and observing. The term is customarily used to refer to relatively complex receptor and neural processes which underlie our awareness of ourselves and our world. This awareness is referred to as perception.

Although the term *perception* is usually restricted to aspects of experience, it has certain behavioral implications. Perception of objects, situations, and relationships is often correlated with particular overt reactions. If we are aware of a difference in the color of apples, we will very likely select the red ones for eating. If we see the detour leading off to the right, we will very likely take it. If we do not see it, we are likely to continue and be forced to turn back later. Perceiving that a package is especially heavy, we use both hands to lift it; otherwise we use one hand. In general, when we perceive a difference between objects, we behave differently toward each of them, and when we do not perceive a difference, we fail to exhibit differential behavior.

Much of our information about perceptual processes is obtained without direct reference to their experiential aspects. Some of this information comes from experimental investigations of animal and infant behavior. Animals and infants can tell us nothing about their experiences, but they do respond differently to certain aspects of their environment. We can train them to approach one color and avoid another, to make one response to a triangle and a different response to a circle, and to differentiate various stimulating conditions. We can then reduce the difference between stimuli and observe the point at which discrimination no longer occurs. Differential responses tell us much about the stimulating properties of an organism's environment. This information may help us to understand receptor and neural development.

ANALYSIS OF PERCEIVING

Whether we look at perceiving from the standpoint of behavior, from the standpoint of experience, or from the standpoint of the response mechanisms involved, it is an extremely complex process. *Receptor functions* play a necessary and a predominant role, but other functions may also be involved. These other functions have a variety of titles, but we shall group them under the two headings, *symbolic* and *affective.*

Receptor processes

Perceiving is often referred to in terms of

the receptor process predominantly involved. We speak of visual, auditory, olfactory, gustatory, kinesthetic, tactual, static, or organic perception. Under most conditions of everyday life, several receptor processes are simultaneously activated. We not only see objects, but we hear, and perhaps even smell them at the same time.

When perceiving is narrowed to a particular receptor process, such as vision, there is still much more to it than reception. The reception which is involved sets off in turn a complicated pattern of neural events which represents former stimulation. For example, the picture of a skunk (visual stimulation) may remind us (symbolic process) of how skunks smell, or give us an image (symbolic process) of the odor. That is to say, we may have more or less vivid experience of the odor, even though it is not present at the moment.

Symbolic processes

Symbolic processes are known by a variety of names. We have just suggested that being reminded of something and having an image of something are symbolic processes. What we commonly call ideas are symbolic processes.[1]

Our earlier discussions of remembering and thinking have pointed out that neural activities aroused by stimulation leave their "trace" or "record" in the nervous system. This trace may then represent, or act as a substitute for, the original situation, activity, and experience. To take a very simple illustration, think of your mother's face. I might have said, "Get an image of your mother's face," "Imagine your mother's face," or, "Recall your mother's face" — it would amount to about the same thing. The image that you get, if you get one at all, may be faint or it may be clear. Unless you are congenitally blind, it is most likely visual. It is somewhat as if you saw the face. The important point, however, is that such an image is dependent on former stimulation when your mother (or a picture of her) was actually present. This stimulation modified your nervous system in some way, leaving a residue or trace. Activation of this trace by certain stimuli may lead you to recall your mother's face. The stimulus may be a whiff of the perfume used by her, a voice like hers, sitting down to a meal such as she prepared, or the instruction, "Get an image of your mother's face." In short, anything associated in the past with your mother's face may activate the symbolic process.

Why do we refer to such processes as symbolic? Think, for a moment, of what we ordinarily mean by a symbol. It is something which represents something else. Words are symbols because they represent objects, situations, or events. They are symbols for us if we know what they represent.

Any present stimulus, in addition to arousing receptor functions, also serves to activate symbolic processes.

Affective processes

It is generally recognized that each perceptual experience may have its affective aspects. We not only see an object and perhaps have images of former sensory stimulation, but the object impresses us as pleasant, unpleasant, or perhaps as neither. Certain forms of stimulation, like a strong electric shock or a needle prick, arouse feelings of unpleasantness, whether or not we have had former contacts with them. Sweet substances probably arouse pleasant experiences from the start. However, the pleasantness or unpleasantness aroused by the sight of a tree, the sound of a voice, or the odor of garlic depends upon our past experience. The odor of garlic, for example, might be pleasant to those reared in its presence and unpleasant to many others.

Analysis of perceiving summarized

We can best summarize the above discus-

sion, and elaborate certain aspects, by referring to a particular perceptual experience. Let us take, for example, the perception of a meal cooking. At least three receptor processes (vision, smell, and hearing) may be involved. Light waves stimulate receptors in our eyes, odorous particles from the food stimulate receptors in our nostrils, and explosions in the fat set up sound waves which stimulate receptors in our ears. Related neural processes are aroused, and we have visual, olfactory, and auditory experiences. We are usually not aware of these experiences as separate. They are aroused simultaneously and are so interrelated (both from the standpoint of the stimulation provided and the central neural processes involved) that the experience is usually a unitary one. It is not analogous to a wall with its separate bricks. Rather, it is more closely analogous to water, with its hydrogen and oxygen not immediately evident.

In addition to receptor functions, symbolic processes are involved. The sight, sound, or odor of food may remind us of former occasions when we have eaten this food. Gustatory (taste) images are perhaps aroused. Although the tongue is not being stimulated at the moment, we vaguely "taste" the food. This is partly because what we call "taste" is to a large extent smell (see p. 475), but also because previous situations like the one to which we are now subjected have been followed shortly by actual gustatory stimulation.

There are also the affective and related processes. If we are hungry, the situation is pleasant. If we are seasick, on the other hand, it may be highly unpleasant. Its pleasantness or unpleasantness may be related to such organic processes as salivation, gastric secretions, and stomach activities.

Aesthetic experience may also be involved in our perception of a situation. We may perceive it as beautiful, ugly, or indifferent. These evaluations depend upon affective processes and also upon recall of past experience. In this way, they overlap the affective and symbolic functions.

WHY WE PERCEIVE WHAT WE PERCEIVE

Preceding discussions have indicated that what we perceive depends upon the arousal of receptor, symbolic, and affective processes. But this does not tell the whole story. We have not pointed out, for example, that some forms of stimulation arouse the same experiences in all of us. These experiences appear to be independent of previous relevant experience. It would be difficult and perhaps impossible to prove that they are inborn, yet there is every indication that they are. We shall refer to them as primitive organizations of experience. Animals, children, and savages behave as if the stimulating properties of some of these situations were the same for them as for us.

What we perceive is also dependent upon the context or general setting of the object, situation, or event. Some of the influences attributable to context are quite primitive, perhaps innate. Others are obviously due to past experience.

The factor of past experience, often referred to as the habit factor, accounts for the different ways in which different individuals perceive certain identical external situations. Moreover, the same individual may perceive a particular situation differently at different times. This brings us back again to the influence of sets or attentive attitudes. Such sets are also dependent upon past experience.

We will now consider some examples of *primitive organization* (certain simple groupings, illusions, relational discrimination). These will be followed by examples of the influence of such factors as *context, past experience,* and *set.*

SOME EXAMPLES OF PRIMITIVE ORGANIZATION

Look at the dots in Figure 185. Although you may never have seen this particular pattern of dots before, it has a certain degree of organization or meaning for you. You see the dots, not as so many dots, but as four groups of dots. You probably noticed the grouping before you observed the number of dots. Moreover, the same general configuration (gestalt) would remain if these were white dots on black; if they were small squares instead of circles; if they were red, or yellow, or blue; and, in fact, if they were any visual objects that one might imagine. In other words, the grouping is independent of the particular parts (the dots, etc.) which serve to represent it.

Even outside of vision, the same grouping would remain. Thus, eight taps with a pencil, eight blasts on a trumpet, or almost any eight auditory stimulations imaginable, would produce the same perceptual configuration if presented in pairs with a perceptible time interval between each pair. Likewise, the essential aspect of the configuration would be retained if one were to arrange points of stimulation on the skin with a large enough distance between each of the paired points (and the pairs of points) to make them discriminable. You would experience four groups of paired points.[2]

The dot example is but one of many used to illustrate primitive groupings. Illusions exemplify primitive organizations that are somewhat more complicated than the groupings illustrated.

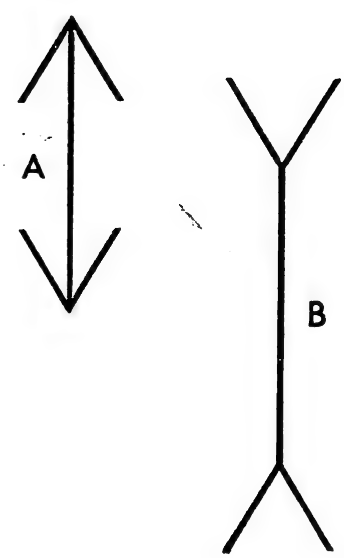
Illusions

Illusions are "false" perceptions. When we experience an illusion, we experience certain things which fail to correspond with the situation as objectively measured. Illusions should not be confused with hallucinations. The latter (see pp. 411–412) may also be thought of as inaccurate perceptions, or, as some prefer to say, dreamlike images which are mistaken for objectively measurable external phenomena. They differ from illusions in certain important respects. In the first place, although we all experience illusions, few of us ever have hallucinations. While normal people sometimes experience them, hallucinations are usually confined to the mentally ill and those under the influence of drugs. In the second place, illusions always have a clearly apparent external stimulus. Hallucinations sometimes occur when there is no apparent objective stimulus. In the third place, the same situation arouses the same illusion in all subjected to

185

A Simple Gestalt

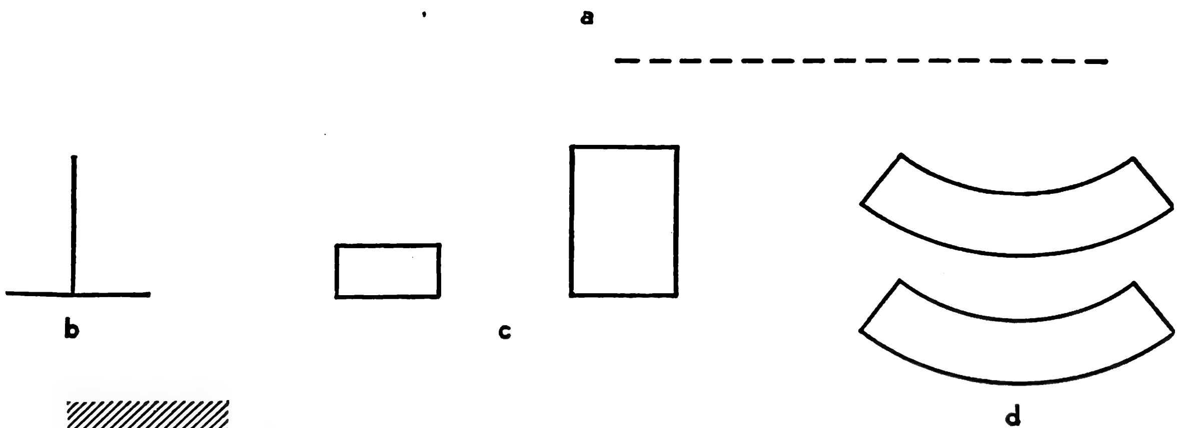
These dots fall into natural groupings independent of past experience. (After Wertheimer.)



186

The Müller-Lyer Illusion

Which vertical is longer, A *or* B?



187 **Some Visual Illusions Observed to Exist in Animals and Human Beings**

a, *Interrupted extend illusion. The distance from end to end is the same in the line with the gap and the line without it.* b, *Vertical-horizontal illusion. The vertical and horizontal lines are equal in length.* c, *Breadth of rectangles illusion. The breadth is identical in both rectangles.* d, *Wundt's illusion. The figures are identical.*

it. That is why we class it with primitive organizations. On the other hand, everybody who has an hallucination under particular circumstances has a different hallucination. When one person sees red devils, another may see snakes, or dragons, or executioners.

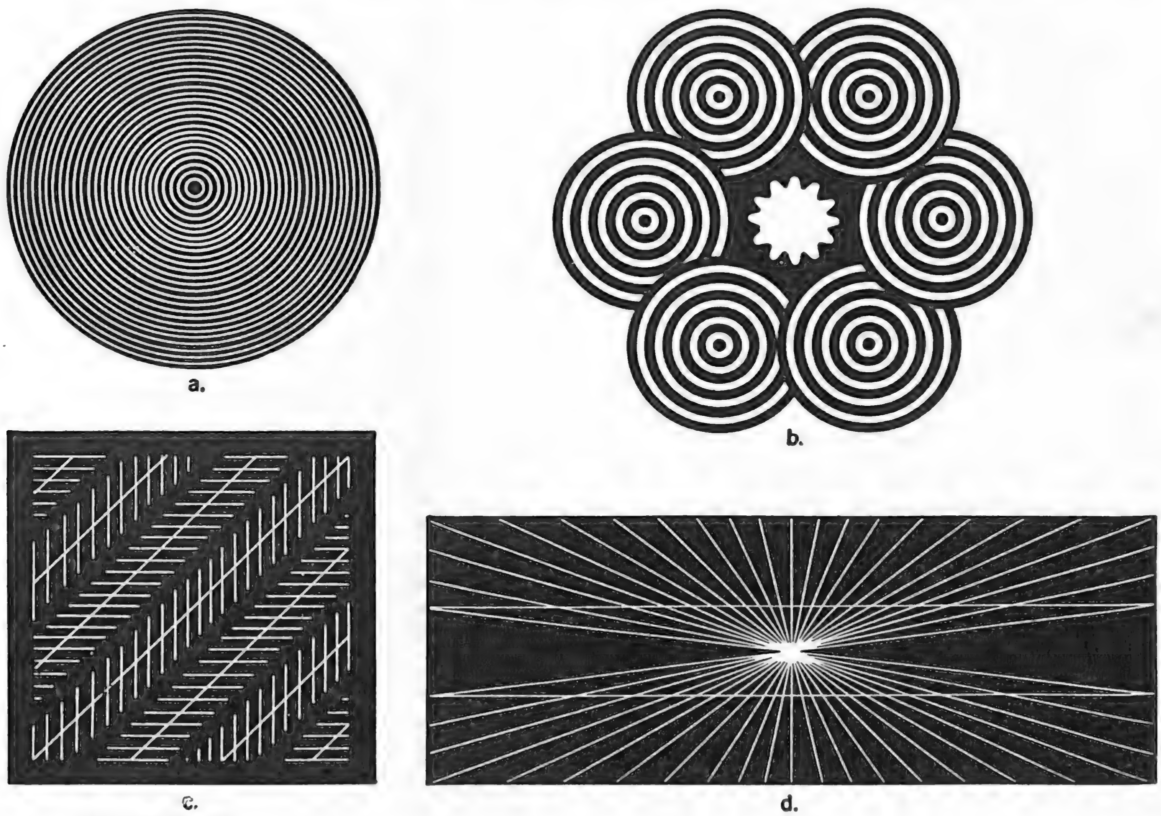
The Müller-Lyer illusion. This illusion is illustrated in Figure 186. You, in common with all other normal adults, will say that the vertical line in *A* looks shorter than that in *B*. Children old enough to indicate the nature of their experience give a comparable report. Some animals react as though they also see what we see. This digest of an experiment with chickens illustrates the procedure and outcome of such an experiment.

Two lines of obviously different length to the experimenter and, as it turned out, of obviously different length to the chickens, were presented in a discrimination apparatus. The shorter line appeared on the right side of the discrimination chamber in some trials, and on the left side in others, the side being alternated in a chance order. The longer line always appeared on the opposite side to the shorter one. The chickens were trained to discriminate between them by approaching the shorter line and avoiding the longer. Whenever they approached the shorter line, they received food. Approaching the longer line brought punishment in the form of an electric shock. After several hundred trials (the number differing from one chicken to the other), discrimination reached an accuracy of from 80 to 90 per cent. The difference in length of the lines was then gradually reduced. Moreover, changes in the figures were made so that the chickens would not be disturbed later by introduction of arrows. It is important to note that the changes introduced could by no means be considered training for perception of the illusion, for they introduced no illusory effects. Finally, two lines of equal length, but each bounded by arrows as in the illustration, were introduced. Most animals continued to discriminate (as accurately as they had discriminated the shorter line) the line that to us appears shorter. It

was, of course, possible that they were reacting to the over-all length of the figure (including ends of arrows) rather than to the horizontal lines as such. That this was not the case was shown by control experiments. When the over-all length of the figures was made the same, by decreasing the length of the line whose arrows flanged outward (the negative figure), there was a marked tendency to choose this, the figure previously avoided. Since the central line of this figure was now actually shorter than that of the other, although the over-all length of the figure was the same, it suggests that the chicks had really been responding to the central line all along.[3]

At least four other illusory effects commonly experienced by man have been demonstrated in the behavior of birds. These are illustrated in Figure 187. Birds have been used in such experiments primarily because their vision is exceptionally good, not because it is thought that they are the only animals susceptible to illusory effects.

The Müller-Lyer and several others of the illusions mentioned may be experienced tactually when made up in the form of rubber stamps and impressed upon the skin.



188

Some Other Visual Illusions

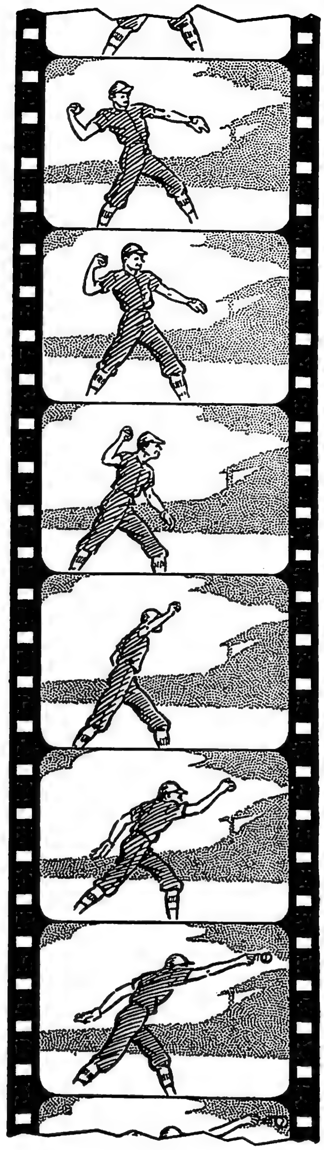
a, *Move the book with a rinsing motion, as if you were slowly rinsing something in a circular pan. Moving radii will be seen.* b, *Again use a rinsing motion. The circles will appear to turn.* c, *The long lines are parallel.* d, *Place a straight edge along the horizontal lines to prove that they are actually straight.* (a *and* b, *after S. P. Thompson, 1876;* c, *Zöllner, 1860;* d, *Hering, 1861.)*

Some visual illusions of greater complexity are shown in Figure 188.

Illusions of apparent motion. We all experience the illusion of movement when we witness a moving picture. In the regular commercial motion picture a sequence of events somewhat as follows takes place: a shutter cuts out all projected light, and a new frame with a slightly different picture on it (Figure 189) moves into place. The shutter then opens, and the picture is projected on the screen. A shutter cuts across this still picture while it remains in position, thus increasing the frequency of flickering interruptions and producing less perceptible flicker. The shutter once again cuts across the field, and a new still frame moves up. The whole sequence is then repeated for that picture. Thus, there is never any objective movement on the screen itself, which would be seen only as a blur, but rather one sees in a moving picture the most beautiful example possible of synthetic movement.

Thus, a succession of still pictures, projected one after the other at a suitable rate, gives us the illusion that movement occurs. This illusion is known as the *phi-phenomenon.* We see it, not only in the movies, but in many electrical advertising signs. The red arrow which appears to move from one position to another does not really move. Two arrows in different positions are flashed on one after the other. Likewise, the greyhound on the bus signs does not really move. We see it running because different positions of the body involved in running are successively lighted at appropriate intervals.

The phi-phenomenon is often studied experimentally by using an apparatus which allows presentation of two or more lights, one after the other.[4] Such an arrangement of lights is illustrated in Figure 190. Experimental research has shown that, in order to get the illusion, one must present the lights at an appropriate brightness, size, distance apart, and temporal interval. If the size, brightness, and distance between the lights are held constant, and you view the situation from a fixed distance, the timing factor may be clearly demonstrated. If there is too long an interval between flashes, you see



189 **Successive Frames from a Motion Picture**

What is projected upon the screen is merely a series of still pictures like these, each slightly different from the preceding one. The perceived motion is thus an illusion.

190

The Phi-Phenomenon

These two circles represent the arrangement of lights in experimental studies of the phi-phenomenon.

one light go on and then the other. There is no apparent movement. If the interval between flashes is too short, you see two lights flashing at approximately the same time. However, if one flash follows the other at an appropriate interval (the interval depending upon the space between the lights, their size and brightness), you see a light move from *a* to *b*. In other words, you see, not two lights, but one. It appears to move across the space where no light actually exists.

This illusion is not confined to human adults. Children and animals behave as though influenced by it. The experiments with cats and guinea pigs are especially interesting.

The animal is clamped into a holder, but with its head free to move. Its eyes face the inside surface of a rotating cylinder covered with alternate vertical black and white stripes. As these stripes move by in a clockwise (or counter-clockwise) direction, the animals exhibit typical right-left head movements (head nystagmus). Thus, their eyes follow a stripe momentarily and then return to the original position. Under normal conditions the nystagmic movements are elicited only when stripes are present and when these are actually moving. Human beings react in a similar manner to such stimulation.[5]

So far we have described the reaction to actual movement of the striped pattern. However, the same reaction occurs when the stripes do not actually move, but are flashed on in rapid succession. This successive presentation of the stripes is produced by use of stroboscopic illumination. The whole inside of the apparatus is dark, except at intervals when the light flashes on. The cylinder moves all the time, but the stripes can stimulate the eye only during a flash determined by the stroboscope. The flashes are synchronized with the moving drum in such a manner that the eye is stimulated only by stationary stripes. Yet the animal acts as though it were being stimulated by moving stripes. These results "seem significant in suggesting that the capacity for apparent movement vision is a fundamental aspect of mammalian vision and is not, as has been implied by some theories, a perceptual capacity based primarily upon some process of learning or acquired perceptual interpretation." The same results are obtained when the cerebral hemispheres are removed. This shows that the phenomenon, at least in guinea pigs and cats, is mediated by mechanisms in the brain stem or retina or both. An explanation in terms of retinal processes has been suggested by recent research.[6]

It has been clearly demonstrated that the illusion of apparent motion is not based upon eye movements, for, with two sets of lights like the pair in Figure 190, but one above the other, an observer simultaneously sees one light moving from *a* to *b* above, and one from *b* to *a* below. In other words, he perceives movement in two different directions at the same time, something which would be impossible if movement of the eyes from one position to the other were necessary. Nor is the phi-phenomenon due to images. If a light moved across the space from *a* to *b*, we might have after-images of it (p. 428). Since it does not actually move, there are no after-images representing intermediate stimulation. The phenomenon is apparently dependent upon some rather stereotyped reactions of our visual recep-

tors, or nervous system, or both, to the stimulus relationships involved.

In addition to the groupings and illusions already mentioned, there are several other illustrations of primitive perceptual organization. One of these is the phenomenon called *perceptual constancy* and the other is *relational discrimination.*

Perceptual constancy

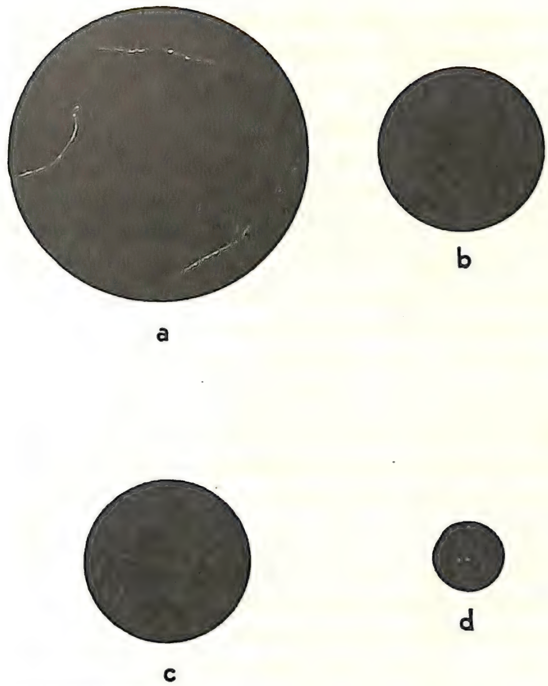
The Müller-Lyer illusion and the phi-phenomenon illustrate that what one perceives does not always correspond with what is before him. The so-called "constancy phenomenon" is a further illustration of this fact, although it perhaps has a quite different explanation. It is the tendency to perceive objects as constant, even though they stimulate us in a variety of ways.

Size constancy is easily demonstrated. Look at some familiar object, say a coin, a pencil, or a book. Hold it close to your eyes. Does the object look smaller as you move it away (thus providing a retinal image of rapidly decreasing size) and larger as you move it closer? The chances are that it does not. It will look smaller only when it is moved much farther away than the length of your arm. Brightness constancy is illustrated by looking at a familiar object and failing to see its brightness change while changes in illumination are introduced. One can illuminate a piece of coal until the amount of light entering the eye is greater than that received from a white shirt, yet the coal will still appear black and the shirt white. Form constancy is exemplified every time we perceive a plate as round when, because of its position with respect to the eye, the image is actually elliptical. Likewise, the square table top is continually seen to be the same square, although, as we look at it from different positions, the image on our retina undergoes a variety of changes. These constancy phenomena are taken into consideration when the artist wishes to create an impression of reality. For example, if he draws a square table top as square from a position in which it is actually impressed upon the retina as a diamond, it looks unnatural to us. He must draw it as a diamond for us to see it as a square.[7]

Relative constancy of perceived objects has obvious utility to the organism. Think of the confusion that would exist if we were to respond to every aspect of our world in terms of its visual image alone. Objects would be seen to shrink or enlarge as the retinal image varied in size, to change their brightness or color as corresponding retinal changes occurred. But, within certain limits, we see things as we "know" them to be despite what the retinal picture alone would tell us. Everything else we know tells us that they are constant. But, as objects move much farther from us, they *do* seem to shrink in size. This change gives us a clue (p. 440) to their distance. Therefore, there must be some sort of compromise between seeing a thing as constant in size (when near) and as smaller in size when far from us. This is, of course, not an explanation of size constancy. We still need to know whether the tendency to make such a compromise is inborn or acquired, or based upon some interrelation of inherent and learned tendencies. If it is learned, we are certainly not aware of how we see things as constant under certain circumstances and as changing under others.

Relational discrimination

Discrimination in terms of relationships has been demonstrated in monkeys and other animals, as well as children. Situations like those used are represented in Figure 191. In a discrimination apparatus, and following the discrimination procedure described above (p. 137), the animal is trained to go to the large circle (*a*) and to avoid the small circle (*b*). After it has learned this lesson well, the animal is con-



191

Relational Discrimination

Trained to select b *rather than* a, *then confronted with the combination* c–d, *the subject usually responds to* d, *the* smaller area, *rather than to* c, *which has the same area as* b. *Positive response to* a *is described in the text.*

fronted with the circle (*c*) and a still smaller circle (*d*). It now goes to (*c*), which is the area that it previously avoided. The animal is not responding to the specific area (*a*), but to the larger of the two areas. Likewise, if we present a larger area than *a* (the area previously selected), the animal now avoids *a* and selects the larger area.

This relational type of response is also found when brightnesses are used, the animal responding to the relation brighter-than or less-bright-than.[8] Animals have been trained to make an absolute response to brightness, but the relational one is obviously more primitive and more easily demonstrated.[9]

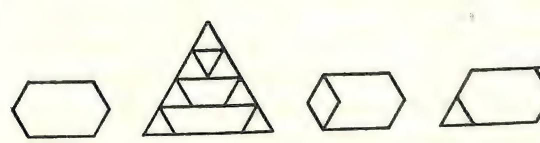
CONTEXT

The total situation in which an object, situation, or event occurs is quite influential in determining what we perceive. We have already seen examples of this in the Müller-Lyer, Zöllner, and Hering illusions (Figures 186, 188 *c* and *d*). Outside of these particular contexts, the lines would be perceived as they really are.

The influence of context is especially evident in puzzles involving hidden pictures (p. 387). It may also be demonstrated by use of geometrical shapes. Look at the first form in Figure 192. It is concealed in each of the other figures. This figure is readily apparent in some, but you may have difficulty in locating it in others.

Still another example of the influence of context is to be observed whenever we enter a moving picture in the middle. It is usually quite difficult to get the thread of the story and, until one does learn what has gone before, he is likely to have difficulty in getting the appropriate meaning from what he sees and hears. It is likewise difficult to identify a song when one merely hears a brief portion of the music, taken out of its context.

With the possible exception of illusions, the examples of context mentioned above illustrate the influence of past experience in perceiving. The items involved are difficult for us to locate or identify because we have been accustomed to experiencing them in another context, or, when they occur in



192

How Context may Conceal a Form

(After Gottschaldt.)

isolation, because we have difficulty in fitting them into the framework of past experience.

PAST EXPERIENCE IN PERCEIVING

With the few possible exceptions provided by primitive organizations, all perceiving is dependent upon past experience — the so-called habit factor. Examples of this are legion, hence only a few need be cited. We shall emphasize perceptual development and the varied interpretations of comparable stimuli.

What we call the meaning of an object, situation, or event is in most instances dependent upon how it has stimulated us in the past, the general context in which this stimulation occurred, and how we reacted to it. Consider, for example, the perceptions which an apple may elicit at different stages of our perceptual development. Before we are old enough to eat an apple, one is perhaps rolled toward us in play. If this occurs sufficiently often, the apple means "something to play with." If balls have also been rolled toward us, the apple may be regarded as a ball. The apple is perhaps identifiable in terms of shape, size, weight, and color. Since all of these aspects stimulate us simultaneously, they may become associated so that any one or a combination of them arouses symbolic processes representing the others. Thus, something with a similar color arrangement and shape (say a picture of an apple) might arouse perceptual experiences somewhat like those aroused by a real apple. After we have eaten an apple, its taste is also associated with its other characteristics. The taste not only enables us to identify the substance as apple, but also may arouse imagery representing other things previously associated with the taste of apple. Moreover, the apple now means something to eat, not merely something to play with. As we learn about Adam and Eve, drink apple cider, eat apple pie, take part in apple dunking contests, learn about apple tree swings, and have love affairs under apple trees, the object "apple" comes to have increasingly rich meaning. Any one of an apple's properties may arouse rich perceptual experience. This does not mean, of course, that we always perceive all of an object's meaning. The point is that we *may* perceive it, in terms of any experience formerly associated with it.

New situations are often fitted, as it were, into the individual's experiential background. Thus, a little girl who saw a caterpillar for the first time called it "a kitty bug." A boy whose dad taught at a college with a clock tower interpreted every other building with a clock tower as a college. Upon further contact with objects and situations, each of us modifies his interpretations. The girl learns that the "kitty bug" is a caterpillar, and the boy learns that not all buildings with clock towers are colleges.

The same object may have quite different meaning to different persons. What is illustrated in Figure 193? Essentially the same stimulation is involved, regardless of who looks at the picture. Some say that it is a crude lamp. It does have a certain similarity with oil lamps. Some say that it is a smudge

193 **What Is This?**

What you see will depend upon your past experience with these or similar things. (From Croll, R. H., Wide Horizons. *Sydney: Angus and Robertson, 1937, facing p. 114.)*

pot such as those used in orange groves. Others say that it is some sort of bug. In short, the perceptual experience differs considerably from one person to another, although the retinal stimulation and sensory processes involved are similar for all. This difference lies in symbolic processes. The present stimulation taps different past experience. Almost any native of Central Australia would say without hesitation that he perceives a honey ant, which is the correct answer. The native's salivary glands would perhaps work overtime, and his perceptual experience might be tinged with pleasure, for this ant, whose body swells up with honey, is a great delicacy for him. He takes the upper part of the body between his fingers and bites off the "honey pot," as we might bite a grape from its stem.

The same principle as that exemplified above — namely, that we often perceive different things although we are similarly stimulated — is quite obvious when reactions of different individuals toward the same person are concerned. A psychiatrist says:

> Think of your mother. If you and I see her at the same time, we certainly see very different persons. I, of course, do not know what you see; but I may see an attractive, mature woman just designed for a pleasant evening, or a fat, frowsy, old bore, or an interesting example of some obscure skin disease.[10]

SET IN PERCEIVING

The sets which play a part in determining what we perceive are attentive sets or preperceptive attitudes. These have already been considered (pp. 385–386) from the standpoint of their role in leading us to perceive. Some of the attentive sets are habitual while others are determined by immediate aspects of a situation, including instructions concerning what we are to observe.

Habitual sets and how they influence what is perceived may be illustrated by reference to specialists in aspects of nature. The entomologist, being an expert on insects, perceives organisms which completely escape our observation. Likewise, an astronomer perceives much more in the heavens than those of us who are not astronomers, even though we too may be gazing at the sky through a telescope. Sometimes, in fact, the scientist's set may lead him to perceive aspects of nature not observed by other scientists. For example, an interesting controversy hinges upon the question of whether or not the planet Mars has canals. Some astronomers "see" these canals. Under comparable conditions of observation, others fail to see them. The different perceptions are probably due to a difference in what the respective astronomers expect to see.

The influence of nonhabitual sets is especially well illustrated by hallucinations. Because we have a set conducive to seeing or hearing certain things, we sometimes "see" or "hear" them when they do not exist.

I once had a colony of white rats in the attic of the psychology building. One afternoon I found several rats outside of their cages. Some were dead and partly eaten. It occurred to me that, however the rats had escaped, they must have been eaten by wild rats. I went downstairs to get some water and was climbing the stairs again when I saw before me, and directly in front of the cages, a large wild gray rat. It was standing tense and trembling, apparently having heard me ascend the stairs. Very slowly I raised a glass jar that was in my right hand, and aimed it at the rat. Much to my surprise, the animal failed to move. Upon approaching the object, I discovered it to be a piece of crumpled-up grayish paper. Without the set induced by my suspicion that gray rats were in the attic, I should undoubtedly have seen the paper for what it was, assuming that I noticed it at all.

Was this an illusion or was it an hallucination? At least it was not an illusion in the sense of a universal inaccuracy or falsity of perception. One might question

whether it was an hallucination because there was an obvious external stimulus present. Regardless of what we call such phenomena, they do illustrate the importance of set in determining what we perceive. In clear-cut cases of hallucinations, as when a person has delirium tremens and sees devils, snakes, or hell fire surrounding him, the particular set may not be apparent. However, since different individuals, and the same individual at different times, hallucinate different things, set probably plays an important role in determining what is perceived under such circumstances.

The influence of instructional sets is illustrated by experiments in which different observers perceive different things, depending upon what they are led to expect.[11] In Figure 194 are shown some typical results. Ambiguous figures, like those in the center, were exposed briefly, one at a time. After each exposure, the subject made a reproduction of what he had seen. When subjects were told that the figure would be like a pair of glasses, they perceived glasses, as indicated by reproductions such as that on the left. When other subjects were shown the same figure under the same conditions, but told to expect a dumbbell, they drew reproductions like that on the right.

REDUCED CUES

As perceptual experience grows, parts of situations come to arouse the same response

Set I Glasses — Stimulus — Set II Dumbbell

194 **How Instructional Sets May Influence What We Perceive**

If the subject had been told that he would see something like bar bells, his drawing would probably have been more like the stimulus than it was when he was told that he would see something like glasses, or like a dumbbell. (After Carmichael, Hogan, and Walter.)

A B

195 **What Objects Are Here Represented?**

(After Street.)

formerly aroused by the entire situation. This is the tendency to respond in terms of reduced cues, an aspect of which was considered in the discussion of remembering (pp. 210–211). Reading provides a good example. Our eyes fixate briefly on a word — too briefly to take in all of the details — yet we grasp the meaning of the word. This is why typographocal errors like those involved in this sentance often pass unobscrved, unless one is looking for them. How many errors were there?

Many people in our culture have little difficulty in identifying *A* in Figure 195 from the cues given. On the other hand, relatively few identify *B*. The reason is that few have had relevant experience with what is pictured. Only those who have observed a photographer kneeling with a graflex camera are able to see the photographer taking a picture. Even some who have had such experience have perhaps had it so infrequently that the cues provided do not arouse the appropriate perception.

We observe instances of response to reduced cues on every hand. When *All Quiet on the Western Front* was shown in a Pittsburgh theater several years ago, and the boom of cannon was heard from the screen, a "shell-shocked" veteran of World War I dove for the orchestra pit (somewhat like a dugout), then emerged, looking very sheepish. We perceive the approach of a friend

in terms of his footsteps or his voice. We recognize acquaintances on the street in terms of some obvious characteristic, or narrow group of characteristics, rather than by a careful over-all scrutiny. As everyone knows, we sometimes "perceive" a friend, only to discover that it is not our friend at all. We have been misled, perhaps, by the stranger's dress, her walk, her red hair, or some other aspect which she shares with our friend.

PERCEIVING DIFFERENCES

How much must two stimuli differ before you can notice the difference? The answer depends on several things. Small differences may pass unnoticed — in other words, may be below the threshold of discrimination — unless you are set to observe them. Let us assume, however, that you are set to observe small differences. Then the answer to our question depends upon (1) the relative magnitude of the stimuli to be compared, (2) the sense stimulated, and (3) the manner in which the stimuli to be compared are presented to the subject.

If three candles are burning in a room and you add one, there will be a perceptible increase in the illumination of the room. As a matter of fact, the change will clearly be perceptible. It will be far above the threshold. However, if one hundred candles are burning and you add one, there may be a just perceptible or just noticeable difference (j.n.d.) in illumination. Suppose, now, that two hundred candles are burning and we add another. No matter how much you are set to perceive a small difference in illumination, you will not perceive the change. It will be below the threshold of discrimination. Likewise, one pound added to two or three pounds (or subtracted from two or three pounds) will lead to a clearly perceptible change in weight. The object will feel heavier or lighter, as the case may be. Add one pound to one hundred, however, and the difference in weight will not be noticed.

In an old psychology text [12] there is a description of an experiment carried out on a frog. The frog sat in water the temperature of which was gradually increased until it reached the boiling point. However, the animal failed to move. It was boiled alive without ever having made an effort to escape. Why? Because the increase in temperature was so gradual (was such a small proportion of the preceding temperature) that the frog could not at any moment sense an increase in temperature. The difference, in other words, was never above the threshold.

These simple illustrations suggest that, whether or not a difference in intensity is discriminated depends upon the ratio of the change in stimulus intensity to the intensity of stimulation existing prior to the change. In other words, whether one discriminates a difference between the intensity of stimulus *a* and stimulus *b* (or a difference in the correlated experiences *a* and *b*) depends upon what proportion the change from *a* to *b* is of *a*. This is known as *Weber's law,* so named because Weber, a German physiologist, first formulated it.

In experimental investigations of Weber's law, one stimulus intensity is held constant and referred to as the standard intensity. We then determine what stimulus intensity can be just barely discriminated from the standard intensity. If Weber's law applies, the increase required is a constant fraction of the standard intensity. This fraction is referred to as the *constant (C).* Where Weber's law applies, the j.n.d. is a function of $\Delta S/S = C$, where S is the standard stimulus intensity, ΔS, the change in S required to produce a j.n.d. in intensity, and C the constant ratio.

If one candle added to one hundred produced a just noticeable difference in brightness, S would be 100; ΔS, 1; and C, 1/100. Suppose that this ratio applied generally to brightness discrimination; then, how many candles would need to be added to five hun-

dred in order to produce a j.n.d. in brightness? The answer is one to every hundred, or five. The increase (or decrease) must be one hundredth of the preceding intensity, the standard intensity.

The Weber ratio (C) varies, depending upon the kind of sensitivity being measured. It is much smaller for visual than for auditory intensity, roughly 1/100 as compared with 1/5. It differs, also, with the range of intensities involved, being constant only within an intermediate intensity range.

There are several psychophysical methods, each of which yields a somewhat different ratio.[13] One of these, the method of just noticeable differences, will serve to illustrate how a j.n.d. for visual length of lines could be determined.

We instruct our subject to indicate which is the shorter of two lines. We then pair the standard length (say, 10 inches) with each of several comparison lines, repeating the presentations many times in all possible combinations and with the standard an equal number of times on the right and left. The difference in length between the standard line and the line discriminated from it with an accuracy of 75 per cent is taken to be the threshold (the just noticeable) difference.

A comparison line of 10 inches would, of course, be selected from the standard length (10 inches) with no greater accuracy than 50 per cent, or chance. The standard length, let us say, is differentiated from a line of 10.5 inches with an accuracy of 95 per cent, from a line of 10.4 inches with an accuracy of 87 per cent, from a line of 10.3 inches with an accuracy of 83 per cent, from a line of 10.2 inches with an accuracy of 80 per cent, from a line of 10.1 inches with an accuracy of 75 per cent, and from a line of 10.09 inches with an accuracy of 70 per cent. In this case, unless a finer determination were desired, we would take 10.1 — 10.00, or .1, as the threshold difference. The Weber ratio in this case would be 1/100.

The psychophysical methods have been used to develop the decibel scale of loudness (p. 450), a scale used by physicists and sound engineers as well as psychologists. These methods have also been found useful in many other fields, including those of educational, social, business, and industrial psychology. They are useful whenever we wish to determine how much difference in something must be present before people can notice it. If some practical situation requires that certain differences be perceived, we make sure that the differences are well above the threshold of discrimination.

SUMMARY

Perceiving has its experiential and behavioral aspects. From the standpoint of experience, it is synonymous with observing differences, relationships, organizations, and meanings. The experiential aspect itself is often spoken of as perception. From the standpoint of behavior, perceiving is synonymous with acting differentially, in terms of relationships, in terms of organized properties of the environment, and in terms of meaning. Perceiving, considered from either standpoint, involves receptor processes and it may also involve symbolic and affective processes.

Most situations of everyday life activate several receptor processes simultaneously. For example, we may see, smell, and hear at the same time. Symbolic processes are representative processes — that is to say, they represent past stimulation. Present stimulation arouses traces left by former associated stimulation. This underlies the imagery aspect of perceiving. Symbolic and affective processes aroused by a situation give meaning to that situation.

Some aspects of perceptual experience and behavior appear to be inborn rather than learned. These have been referred to

as primitive organizations. Among the examples presented were primitive groupings, some geometrical illusions, the illusion of apparent motion, perceptual constancy and relational discrimination. In some instances, as in the illusions, we actually perceive as aspects of our environment certain phenomena which have no objective existence. Thus, we may see movement where none occurs, and we may see straight lines as bent, or lines of equal length as differing in length. Since the same illusions are experienced by persons who have never before been presented with such situations, and since animals react as though subject to the same illusory effects, there is good reason for believing that the organizations involved are independent of previous experience.

Illusions, and possibly other forms of primitive organization, are apparently imposed upon us by the organism. The external situation activates certain receptor and neural processes, but what we perceive corresponds with these processes and not with the external situation. Thus, in the phi-phenomenon, we perceive movement because of some process within the eye or nervous system, not because of some external movement. A large amount of research is being focused upon primitive organizations with the aim of finding out what receptor and neural activities are responsible for them.

Context, or the setting of an object, situation, or event, plays an important part in determining what we perceive. This is illustrated in certain illusions, but it is also illustrated in all perceiving which depends upon past experience. Some good examples are finding a hidden figure; locating familiar objects when, for purposes of camouflage, their surroundings have been changed; trying to get the meaning of what we see and hear when, as in entering a movie in the middle, we do not know what has gone before; and in identifying music when we hear only brief excerpts. In most instances the influence of context is related to past experience.

The significance of past experience is especially evident when we trace the development of perceiving in children. Any object familiar to us as adults has acquired a variety of meanings because of its association with other objects and events in the past. Thus, perception of an apple is eventually possible in terms of any one of its aspects (such as color, odor, taste), and any one of these is likely to arouse symbolic processes which represent former experiences or activities in which apples have played a part. Growth of meaning is also related to our tendency to interpret the new in terms of the old. Think, for example, of the little girl who called the caterpillar a "kitty bug" when she saw one for the first time. That the same object may have different meanings for different individuals, even though it stimulates them identically, can be illustrated by use of any object not familiar to all. One will recall the picture of the honey ant in this connection.

The influence of set in perceiving is another example of the role of past experience, for the set is itself determined by what has happened previously. Different expectations may lead different people to perceive the same object as different. Think of the "gray rat," which was really a piece of paper, and of the drawing that one subject saw as a dumbbell and the other as a pair of glasses, depending upon what expectations had been aroused.

If we had to examine every object or situation carefully before perceiving it, we should be greatly handicapped in reacting to our environment. What we do, characteristically, is to react to the whole in terms of a part. Some aspect of former experience, or some part of a present familiar object or situation, arouses symbolic processes which, as it were, "fill out" the experience. In reading, we grasp the meaning of words by reacting to their most obvious letters, or parts

of letters, rather than by reacting to all of the letters individually. We recognize familiar objects in terms of their parts, as in the horse and rider illustration (p. 412). False recognition of other persons illustrates the same phenomenon.

In order to perceive two forms of stimulation as different, it is necessary that the difference between them be a certain fraction of one, which is referred to as the standard stimulus. This is the essence of Weber's law. If you are to discriminate an increase in brightness, the increase in intensity of light must be about one hundredth of the intensity that you started with. This increase is necessary to bring the difference above the threshold of discrimination, or to produce a just noticeable difference (j.n.d.) in brightness. In hearing, taste, and the other senses, different ratios apply. In every field of reception, they apply only to the middle range of intensities, they vary somewhat from one individual to another, and they vary under different experimental conditions. Similar ratios apply to certain aspects of the environment other than intensity — for example, length of lines. One of the methods used to obtain Weber ratios is that of just noticeable differences.

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18 VISION

Terminology • Visual Stimulation • Some Phenomena of Color Vision: Laws of color mixture; color weakness and color blindness; color zones of the retina; after-images; simultaneous contrast • Some Structural and Functional Correlations: Cones; rods; visual acuity; flicker; retinal interaction; the pathway from eye to brain • Visual Space Perception: Size; depth and distance; physiological cues; psychological cues • Summary

WE HAVE ALREADY CONSIDERED the development of visual mechanisms in organisms ranging from ameba to man and we have observed that the organism's world becomes enlarged and diversified as such mechanisms become increasingly complex. We have also described certain aspects of visual perception — fluctuations of figure and ground, visual groupings, geometrical illusions, the phi-phenomenon, perceptual constancy, relational discrimination, and perception of just noticeable differences in visual intensity. In none of these discussions, however, has vision itself been emphasized. Rather, we have called attention to general principles of perceiving which are applicable to certain other senses as well as vision. We have not raised such questions as "What happens when receptor cells are stimulated and the effects of this stimulation are transmitted to the brain?" In other words, our discussion has not been especially analytical. We now approach visual perceiving more analytically. Certain elementary aspects are considered from the standpoint of their dependence upon stimulation, and upon receptor and neural structures and functions.

TERMINOLOGY

In their visual appearance, aspects of our world differ in color, size, shape, movement, and other characteristics. Here our prime interest is in color, a term used to represent not only what we normally refer to as color but also white, gray, and black. Technically we distinguish between *achromatic* and *chromatic* colors, the former being what is popularly regarded as without color. The difference is well represented in a black and white (achromatic) as compared with a technicolor (chromatic) movie. There will be more about this distinction later.

Before turning our attention to visual stimulation, it is necessary to point out certain basic distinctions between the physical, physiological, and psychological aspects of vision. The two gray circles in Figure 196 will illustrate these distinctions. What our eye receives from the gray areas is reflected light. A physicist upon measuring this light will tell us that its amount and other characteristics are the same in each case. From this fact alone, we might expect the two circles to look identical. But our expectation is not confirmed. Anybody looking at the circle surrounded by black will say that it looks much lighter than the other. However, if we look at a restricted part of either circle through a tube (or both at the same time through apertures at the proper distance apart) we observe that they appear alike. Our observation, under these circumstances, corresponds with the physicist's statement that their reflectances are equal.

The *physical aspect* of visual stimulation from any surface is the reflected light. Its *physiological aspect* is the effect of this re-

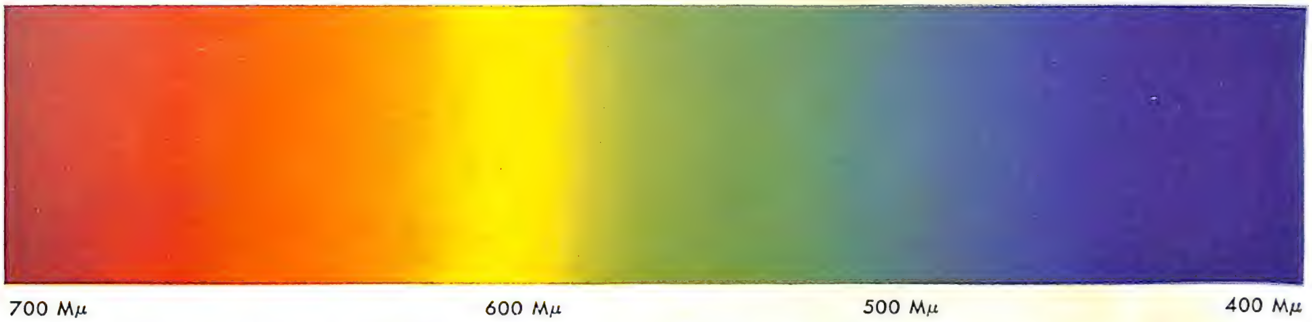


Plate I. The range of wave lengths correlated with vision. One millimicron (mμ) is a thousandth of a micron and one micron (μ) is one thousandth of a millimeter. Thus one millimicron is a millionth of a millimeter.

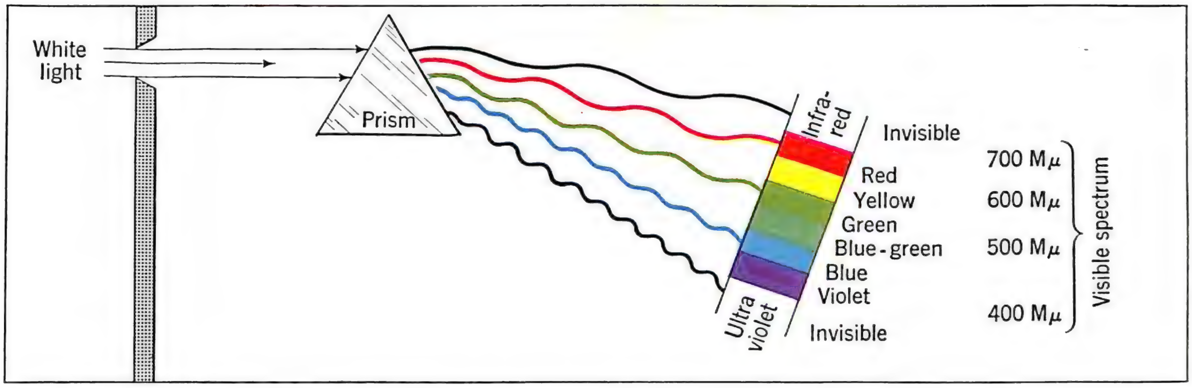


Plate II. How different components of white light are separated to produce the visible spectrum

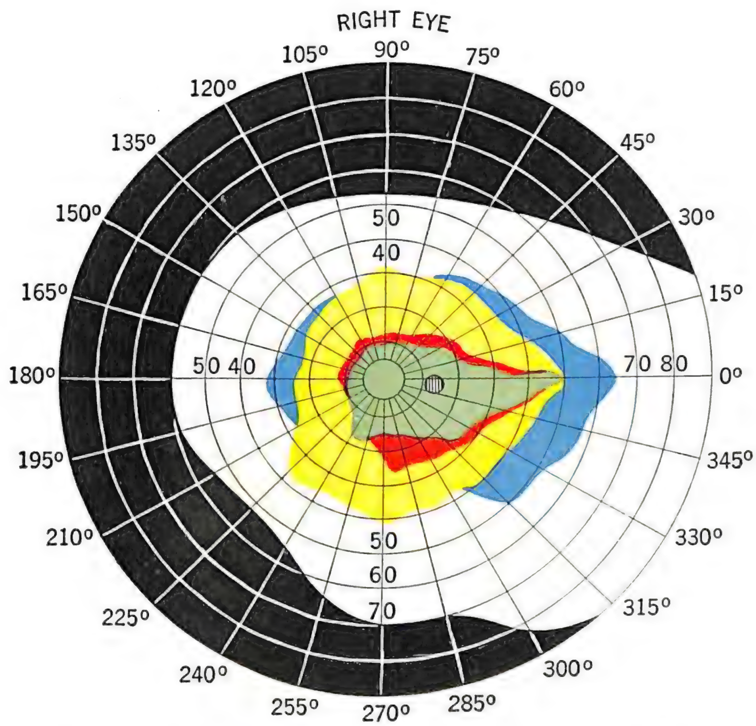


Plate III. A chart illustrating color zones of the retina (see text)

Plate IV. Figure for the detection of color blindness. The normal eye sees the figure 5, the color-blind eye sees the figure 2 (see text). (Copied by permission from Ishihara's "Series of Plates Designed as Tests for Color Blindness," Tokio, 1920.)

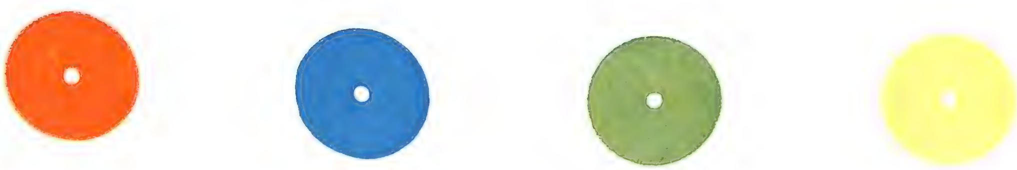
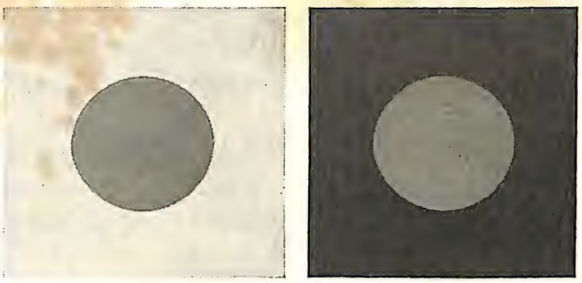


Plate V, Stimulus patches for observing negative after-images. Look intently at the small white circle in the center of each colored area for thirty seconds, then look at a white area. You will see the complementary color.



196

Two Circles of Equal Reflectance but Differing in Lightness

For explanation, see the text.

flected light on the eye and brain. The effect of light depends upon the type of eye into which it is reflected and also, as we shall observe in more detail later, upon whether that eye has been in (is adapted to) light or dark.

The *psychological aspect* (what is seen) depends upon the physical and physiological aspects, but it is not a simple resultant of these aspects. One cannot, from these alone, predict what will be seen. The brightness of the two circles when they were seen through apertures, so that they lost their surface characteristics and context, was equal; an observation which agreed with what we knew about the respective reflectances. But when the grays were seen in the total context of the illustration, configurational and contrast factors were present which prevented them from appearing equally bright.

Reflected light viewed through an aperture so that it is no longer perceived as an aspect of a surface or object is referred to technically as an *aperture* or *film* mode. In the illustration, for example, we looked through an aperture and saw the area as gray, abstracted from any particular object or situation. If we look through a tube at the blue sky, at a red book, or at anything in such a manner as to exclude all but its blueness, redness, or the like, we are again observing an abstracted (aperture) color. Most of the ensuing discussion is concerned with color from this aspect. Here the term *brightness* is clearly applicable.

Colors seen in everyday life as aspects of objects or surfaces are called *surface colors.* Their appearances, as we have seen, are not predictable from the isolated physical and physiological facts alone. It is in respect to these modes that color and brightness constancy (p. 408) applies.

In recent years both psychologists [1] and physicists [2] have come to distinguish between *brightness* and *lightness* by applying the former to aperture colors and the latter to surface colors. Thus, referring again to our illustration, the grays seen through apertures were equally bright, but those seen in their context, as aspects of a surface, differed in lightness. When two grays are seen to differ as aperture colors, we say that they differ in *brightness.* But when they are physically alike but look different because of their surroundings, we say they differ in *lightness.*

In addition to the terms *brightness* for the intensive aspect of aperture colors and *lightness* for the corresponding aspect of surface colors, two other terms are used to describe the chromatic world. One of these is *hue.* It refers to what we commonly call color. The reds, blues, greens and yellows of the spectrum (Plate I) are hues. The other term which applies to chromatic colors is *saturation.* This refers to the amount of a given hue, to its purity, or to its richness. Thus a yellow that is hardly distinguishable from white or gray is not a well-saturated yellow. Think of adding a red dye to water. At first the water becomes pinkish, then, as you continue to add the dye, it becomes increasingly red. You are increasing the saturation of the red.

The distinction between hue, brightness, and saturation, all applied to aperture (film) colors, is now to be considered from the standpoint of stimulus aspects.

VISUAL STIMULATION

Physicists describe light without regard to visual reception. They look upon it as composed of electromagnetic waves, waves of radiant energy emanating from a source, ultimately from the sun. Radiant energy encounters various sorts of matter which, according to their properties, affect it in a number of ways. They may, for example, slow it down, bend it, absorb it, or reflect it. In being reflected light rebounds somewhat like a rubber ball from a hard surface. If it enters the eye it becomes a visual stimulus. Some surfaces (like black velvet) absorb practically all of the radiant energy. This is why they appear black, in contrast with objects which reflect more radiant energy. Surfaces which reflect almost all of the energy appear white. Some reflect certain wave lengths of light and absorb others. These give rise to chromatic vision.

Our eyes are attuned to electromagnetic waves ranging in length from slightly below 400 to slightly above 700 millimicrons * (Plate I). Radiant energy with a wave length of 700 millimicrons has "crests" or pulsations 700 millionths of a millimeter apart. Waves outside of the narrow range of "visible light" fail to excite the eye and thus are not "light," although we speak loosely of infra-red light (over 700 millimicrons) and of ultra-violet light (below 400 millimicrons).

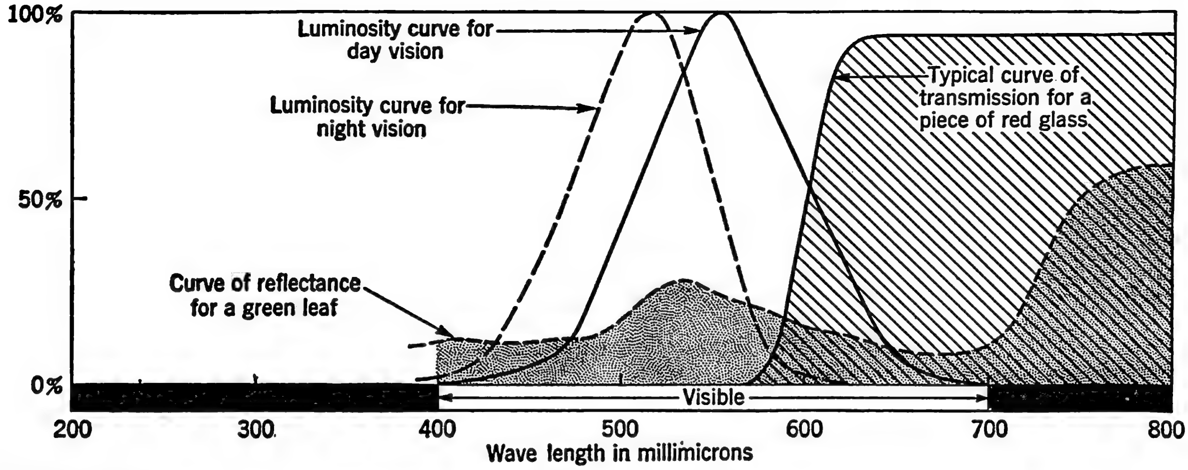
When sunlight is passed through a prism, as illustrated in Plate II, the rays are refracted (bent) away from their course. Interestingly enough, light of shorter wave lengths is bent more than light of longer wave lengths. White light, composed of all visible wave lengths, is caused by a prism to fan out into a series of separate hues. The longer waves, those refracted least, appear red. Slightly shorter waves, bent slightly more so that they fall in a different place, appear orange. Beyond them, in the familiar order of the rainbow, or visible spectrum, are yellow, green, blue, and violet. Some of the important correlations between wave length and hue are shown in Plates I and II.

Figure 197 provides further illustration of these and other relations between the wave length of radiant energy and visual phenomena. Observe the "transmission curve" for a piece of red glass and the "absorption curve" for chlorophyll, which gives leaves their green color. The red glass derives its color from the fact that when it is held between the eye and the sun, it transmits only the longer wave lengths. The other wave lengths are absorbed by the glass. A green leaf absorbs most wave lengths except those in the middle (green) region. These are reflected into the eye, allowing us to see the leaf as green. Colors, then, are not inherent in the objects themselves, but depend upon the wave lengths which they pass into our eyes. Actually most objects transmit or reflect not a single wave length (i.e., homogeneous or *monochromatic* light) but a complex assortment of wave lengths. Note, for example, that chlorophyll to some degree reflects from about 400 to over 700 millimicrons. The color perceived depends on the way in which the color receptors in the eye respond to such complicated mixtures.

Although our visual receptors are sensitive to wave lengths between approximately 400 and 700 millimicrons, they are not equally sensitive to all parts of this visible band. As illustrated in Figure 197, the maximum visibility of the wave lengths is greatest for those in the middle range. Thus the sensitivity curve for day vision is at its maximum around 550 millimicrons, and tapers off in both directions from this region. It is at its minimum in the regions of 400 and 700 millimicrons.

The region of the spectrum to which we are most sensitive is different at night from what it is in the daytime. With the relatively high energy levels encountered during the day (or in a well-lighted room at night) the

* A millimicron is a millionth of a millimeter.



197

Selectivity for Light of Different Wave-Lengths

The graphs above show the per cent of light, at each wave length, which is:

(a) *transmitted,* by a typical piece of red glass.
(b) *reflected,* by a green leaf.
(c) utilized by the eye in the sensing of *light.*

Note how the red glass passes chiefly the light above 600 millimicrons. It is opaque to the shorter wave lengths. Of the visible wave lengths, the leaf reflects most strongly in the middle (green) region. The higher reflectivity of the leaf above 700 millimicrons is of no visual consequence since it is outside of the visible band. The relative sensitivity of the human eye to these various wave-lengths is shown in the two *luminosity curves.* In daylight we are most sensitive to light in the neighborhood of 550 millimicrons. Sensitivity above 700 or below 400 millimicrons is negligible. When the eye is dark-adapted (night vision) the peak of sensitivity is at about 510 millimicrons. Vision under this condition is of course achromatic.

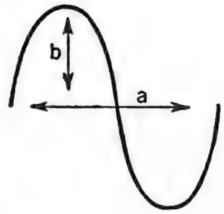
The percentages given for the glass and the leaf represent the actual per cent of energy of each wave length transmitted or reflected. The luminosity curves show the per cent of maximum sensitivity; that is, all values are relative to the peak sensitivity which has been arbitrarily given the value 100. (From various sources.)

eye is maximally sensitive to wave lengths in the neighborhood of 550 millimicrons. At night, when the eye has become accustomed to the darkness, it responds maximally to light whose wave length lies around 510 millimicrons. The peak of sensitivity is thus shifted toward the violet end of the spectrum. As a consequence of this shift, blue and violet gain in relative brightness, as against red and orange.

To demonstrate the above shift, which is known as the *Purkinje phenomenon,* select two pieces of paper, one red and one blue, which in daylight appear equally bright. Examine them again under feeble illumination, after your eyes have become accustomed to the darkness. The red paper will now appear black. The blue paper, while its blueness will not be apparent, will have lost much less of its brightness. It will show up pale in the gloom.

You can also observe the Purkinje phenomenon by looking at a varicolored garden or carpet as darkness falls. Note that the brightest colors under conditions of good illumination are yellow and red. As darkness falls, however, these become less bright. Green and blue, which are relatively dark in daylight, now become brighter than yellow and red. The last objects that one can see, in terms of their brightness, are green and blue. We see the green leaves of a rosebush long after the red roses have disappeared.

The extent of the Purkinje shift can be



198

Wave Length and Amplitude

a, *Length.* b, *Amplitude. The length of light waves is correlated with hue; their amplitude with energy level, hence brightness.*

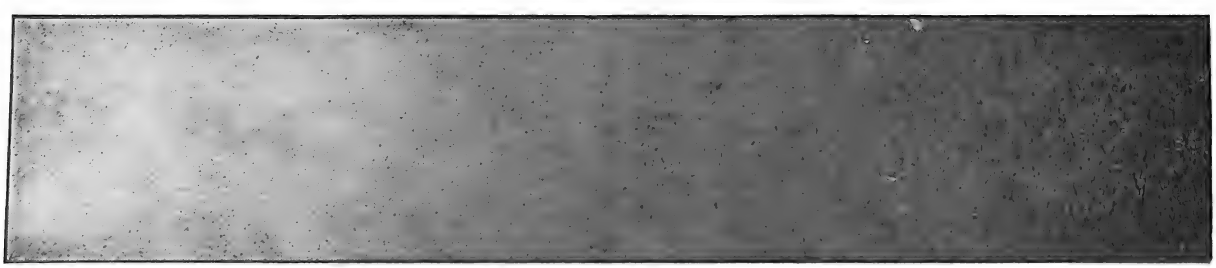
seen by examining the two luminosity curves in Figure 197. This shift, as we shall observe shortly, is due to the fact that we have two sets of visual receptors, one for high and the other for low light intensities.

Saturation is correlated with the complexity of light waves. Monochromatic light is most highly saturated. Mix white light (a combination of all wave lengths) with it and it becomes "washed out" in appearance. Mix two diverse wave lengths and both lose their saturation. Blue and green, for example, become less blue and less green when mixed. We get a greenish blue or bluish green.

Brightness, as we have seen, varies with wave length. Intermediate wave lengths of the visible spectrum have a greater brightness level than those toward either end. The amplitude (Figure 198) of light waves determines their energy level. Hence it is also a correlate of brightness. But one must not assume that brightness is directly proportional to amplitude, for adaptation of the eye determines how bright a given physical intensity will appear. Think of what happens every time one enters a moving picture theatre from bright sunlight. At first the seats and people cannot be seen. Several minutes of adaptation are required before they become visible. The external intensity does not change, but visibility changes greatly. This is *dark adaptation.* As one goes from the theatre into the sunlight he is at first almost blinded by the glare. Very shortly, however, *light adaptation* occurs, and the apparent brightness is reduced to a more comfortable level. Again, the physical light intensity does not change. Adaptation of the eye is alone responsible.

Lightness is even less predictable than brightness. Think again of the two gray surfaces with equal reflectances (wave composition and energy level) yet differing a great deal in lightness.

Lightness constancy (in certain books, referred to as brightness constancy) is a further example of our inability to predict the lightness of an area from physical intensity. Black velvet looks black despite high illumination and a sheet of white paper still looks white even under low illumination.



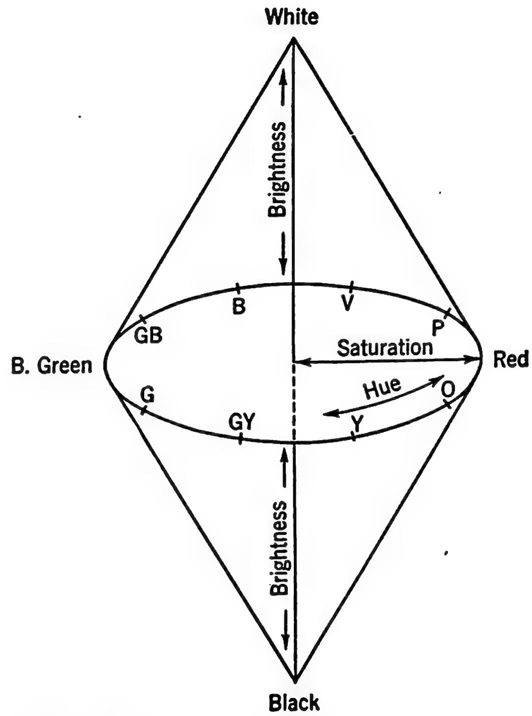
199

A White-Black Continuum

This is not a complete representation of the continuum, for there are well over 500 discriminable steps in brightness from white to black.

The range of visual intensities is represented as a continuum (Figure 199) with black at one end and white at the other. Neutral brightness is assumed to correspond with neutral gray, the mid-point in the continuum. Colors are said to have neutral brightness when their brightness aspect matches that of neutral gray. Likewise, two or more colors are said to be of equal brightness if the brightness of each can be matched with a particular gray in the continuum.

The color solid. The relations between hue, brightness and saturation are illustrated in Figure 200, which shows one type of color solid. Hues of neutral brightness and maximum saturation are represented on the circle where the two cones join. Note that the order of hues on this color circle is the order observed in the spectrum. It is as though the spectrum were curved to form a circle. However, the ends of the spectrum are represented as if joined by purple, a color which does not appear in the spectrum but is produced by mixing light from the red and violet regions. Brightness is represented by a line running through the center of the solid from white to black, with neutral gray at the mid-point. This is the black-white continuum of Figure 199. The most highly saturated hues are represented as equivalent in brightness to neutral gray. As the brightness value of a hue increases (approaches white) or decreases (approaches black), the color becomes less saturated. Because it approximates the gray with which its brightness corresponds, it is represented as approaching the white-black continuum as it moves from neutral brightness in either direction. Any decrease in saturation is represented by a line running from the surface of the solid toward the center. This is why the most saturated hues are represented as falling farthest out on the surface of the figure — at the region where the two cones join. The least saturated colors are those at either end of the solid and those anywhere within the solid represented as close to gray.



200

A Color Solid

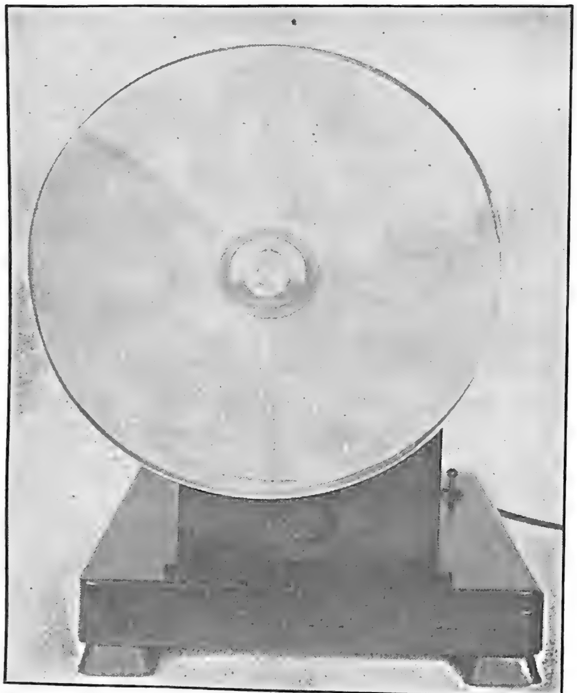
The relation between hue, brightness, and saturation is shown by conceiving of the range of colors as varying, in a tridimensional solid, around the white-black axis. Mid-gray is represented as in the exact center. The most saturated hues, at any brightness level between white and black, are represented as on the outside of the solid. Hues decrease in saturation as the white-black axis is approached.

SOME PHENOMENA OF COLOR VISION

Several phenomena of color vision have been investigated extensively in the psychological laboratory. Among these are color mixtures, color blindness, peripheral color vision, after-images, and simultaneous contrast.

Laws of color mixture

The color solid not only represents the relations between hue, brightness and saturation, but it also represents the laws relating



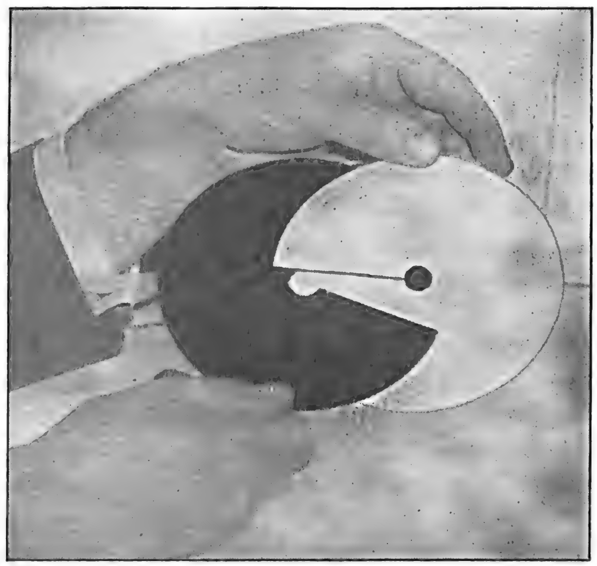
201

A Color Mixer

This is a small electric motor the shaft of which is adapted to hold the disks shown in the illustration below. As the disks are rotated rapidly, the two colors seem to merge so that a single color is seen. (Courtesy of Ralph Gerbrands.)

to mixture of colored lights. A common method of demonstrating these laws utilizes an apparatus like that shown in Figure 201. Disks differing in color are locked together, as illustrated in Figure 202, and placed on the shaft of the motor. As the disks rotate, each point on the photosensitive surface (retina) of the eye is stimulated now by one color and now by another. If the succession of retinal stimulations is too slow, a marked flicker occurs. As the mixer speeds up, flicker disappears and a uniformly distributed gray, or a hue, becomes apparent.

The first law of color mixture is demonstrated by mixing two complementary colors, like yellow and blue. If these hues are mixed in the proper proportions, a uniform gray is obtained. The gray lies between the brightness of the respective colors. Thus, if we use a dull blue and a bright yellow, the resulting gray will be of approximately intermediate brightness. The first law may be formulated somewhat as follows: *Retinal mixture of complementary colors in the proper proportions produces a gray the brightness of which lies between that of the respective colors.* This fact is represented in the color solid by placing complementary colors opposite each other so that a straight line drawn from one to the other passes through a point on the white-black continuum. Thus, if you wish to know which color is complementary to another, just line up a straight edge with (1) the point on the color circle representing that color and (2) the center of the circle. The other point on the circle which falls in line with these



202

Disks for Color Mixer

Disks may be linked in this way to produce mixtures of two or more colors. These disks are arranged for a motor turning clockwise. If they were rotated in a counter-clockwise direction with great rapidity, air currents might rip off a disk, in this case the white one.

two points represents the complementary hue. The complement of red is thus seen to be blue-green.

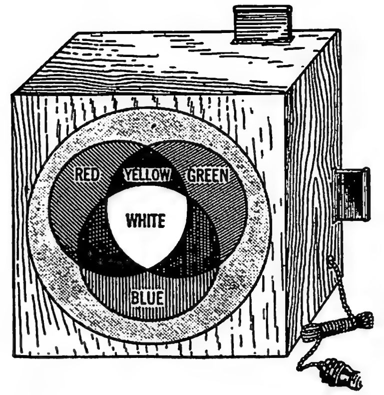
The second law of retinal color mixture says that *if non-complementary hues are mixed in appropriate proportions, the resultant will be a hue which falls between them in the color circle.* For example, a mixture of blue and green produces blue-green, a mixture of red and yellow produces orange, and a mixture of red and blue produces purple. The brightness of the mixture lies between the brightness of the component colors. Its saturation depends on the distance between the component hues on the color circle (Figure 200). If they are opposite, of course the saturation disappears and we have gray — an instance of the law of complementaries. But if they are not opposite, yet far apart, the saturation of the mixture is low. If they are close together, the saturation is high.

The third law of color mixture takes us back to complementary colors. One will recall that a mixture of red and blue-green yields gray and that a mixture of blue and yellow also yields gray. The third law of color mixture points out that *a mixture of mixtures which themselves yield gray will also yield gray.* In other words, if we mix red, blue-green, yellow, and blue in proportions which correspond to those involved in the red and blue-green and yellow and blue mixtures, the result will be gray. If the two original grays differed in brightness value, the brightness of the mixture will lie between them in brightness. There are other laws of retinal color mixture, but the three cited are the most important.

When lights of different wave lengths are "overlapped" by using an apparatus like that shown in Figure 203, the results indicated are obtained. The area where all three colors overlap is a light gray or white. Red and blue produce a purple and green and blue a blue-green. Where the red and green overlap, yellow is produced. A certain red and green, when mixed on a color wheel, also produce a yellow, or what some might call a yellowish gray. Obtaining yellow by mixing red and green is of especial importance for the Young-Helmholtz theory of color vision to be discussed later.

Yellow is also produced binocularly, when one eye is stimulated with red and the other with green. These colors are transmitted by monochromatic filters, one over each aperture of a stereoscopic device (see p. 439). While his eyes are thus stimulated, the subject fixates a bright light equidistant from the filters. This light is backed by a white screen. What the subject sees is a patch of yellow between patches of red and green. Since each eye is stimulated by only one color, red or green, the yellow cannot be generated by the eyes. It must come from some fusion process in the brain.[8]

The reader has perhaps been struck by the fact that yellow and blue light mixtures



203

Singerman's Color Mixture Apparatus

Three circles of light are projected onto the milk glass screen from color filters at the back of the box. The colors involved are green, red, and blue. Where the light from all three circles overlaps, white is seen. Overlapping of green and red produces yellow, overlapping of green and blue produces blue-green, and overlapping of red and blue produces purple. (Courtesy of Chicago Apparatus Company.)

produce white or gray whereas the artist mixes yellow and blue pigments, and the printer overlaps yellow and blue ink, to produce green. There is a simple reason for this difference.

Light mixtures are additive. They add different reflectances. Mixtures of pigments and inks are subtractive, the results coming from what is absorbed more than from what is reflected. Yellow pigment absorbs all wave lengths but those for yellow and green. Blue pigment absorbs all wave lengths but those for blue and green. When the pigments are mixed, the blue and yellow reflectances cancel, leaving only green.

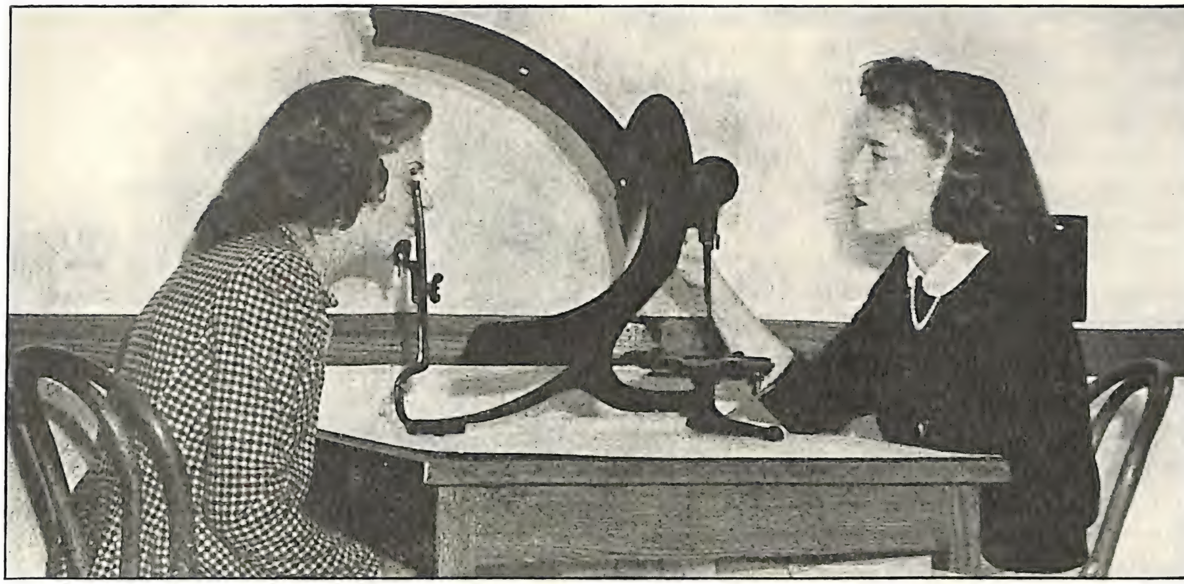
Color weakness and color blindness

Many people have lower than normal ability to distinguish hues. Those who can see the various hues, but merely have certain difficulties in distinguishing them, are said to have a *color weakness.* Those who fail to see any hues are said to be *totally color blind.* Such individuals are quite rare. The few studied by psychologists have shown that the spectrum, for them, is equivalent to a series of grays. The color blindness which we hear about most frequently is *red-green color blindness.* A very much larger percentage of males than females is red-green color blind, but the percentages given differ greatly from one study to another.[4] There are several kinds of red-green blindness, but all show inability to distinguish red, green, or red and green, from grays of corresponding brightness value. Blindness for blue, yellow, or both, is extremely rare.

Actually, as suggested above, it is not correct to say that some people have color vision and some do not, as if all could be divided into two types on this basis. There are, of course, the totally color blind. The rest of the population varies from those with extremely poor color vision to those with extremely good color vision. Most of those with extremely poor color vision are red-green blind to a high degree. Most of the remaining color defectives, rather than being color blind, are color weak, the particular weakness varying a great deal from one individual to another.

There are many tests of color blindness, but one of the most convenient is the Ishihara Test from which Plate IV is reproduced. If you show this chart to a person with red-green blindness, he will see the figure 2. The person with normal color vision sees the figure 5. If you observe the chart closely, you will notice that the disks which make up the figure 5 differ from the background in hue, but that their brightness differs in a random manner over a wide range and is not distinguished from the brightnesses of disks outside of the figure. This random arrangement of disks with respect to brightness makes it impossible for an individual who is red-green blind to see the number. Now look at the disks again. You may notice that certain disks of different brightness from the others are arranged systematically to form a figure of some kind. It is the figure 2. You will have difficulty in tracing this figure; your set for hue may make it impossible for you to do so. However, the individual who cannot see the hues, but who is especially set for brightness, cannot help seeing the figure 2. It stands out as plainly for him as the 5 does for you.

Many people with defective color vision do not recognize their defect. The reason that they are not aware of the deficiency is that they have learned to give color names to familiar objects in terms of the most characteristic brightness of these. Thus, red, to one type of red-green defective, is equivalent in stimulating value to dark gray. He calls either the red object or the dark gray representation of it red. This is because, when earlier stimulated by the "red" object, he has heard it called red. Likewise, a person with green color blindness will often call a brown sweater of a certain brightness value green. It looks no different to him



204

A Perimeter

The subject (left) is fixating the small white circle in the center of the perimeter arm, while the experimenter turns a small wheel which brings the color on the upper part of the perimeter arm toward the center. The subject's left eye is of course closed.

from the way a green sweater of the same brightness value looks.

Color zones of the retina

As illustrated in Plate III, a certain region of the retina is completely color blind and another region red-green blind. Moreover, as also indicated on the chart, one small area in each retina is completely or almost completely blind. This is known as the *blind spot.* It is situated at the point where the optic nerve leaves the eye.

The color zones of the retina and the area of the blind spot may be mapped by using a perimeter such as that illustrated in Figure 204. With one eye closed and the other fixating a point in the center of the perimeter arm, the subject observes, out of the corner of his eye, the color of a small disk which the experimenter moves from the extreme periphery of the arm inward, or from the center of the arm outward.

Suppose, for example, that the colored disk is red. In the center of the retina (see chart) red, like all other colors, is readily observed. As the red disk is moved at a steady rate from the fixation point outward, it eventually reaches a region where the observer no longer sees it as red, although he may see it as dark gray, or as round, or as something moving. The number of degrees from the center at which red disappears is noted. Now the disk is moved from the periphery toward the center. The observer reports when he again sees red, and the position is noted. Sometimes the color disk is presented at the extreme periphery, and the subject does not know what color is being used until the disk is moved far enough in for him to observe it.

The procedure may be repeated several

times on the same axis for each of the colors and also on each of the several axes of the eye — up-down, nasal-temporal, upper right and lower left, and so on.

Accurate results are obtained only so long as the observer keeps a constant fixation of the central point while he is observing, and so long as the illumination of the visual field remains constant. The color zones vary a great deal under different conditions of illumination, since they are extended as the illumination of the test object is increased. They also differ markedly from individual to individual.

Under constant conditions of illumination, the results obtained in measuring peripheral color vision are, in general, as follows: all colors are seen in the center of the visual field. As the red or green test object is moved from the center outward, however, it reaches a region where it is no longer observed as red or green. Yellow and blue are observed over a more extended area, but these also drop out. One of them sometimes drops out before the other. Beyond the region where blue and yellow are no longer seen, the observer still sees gray and white. He is also readily stimulated by visual movement. The shape of objects, however, is not clearly perceived. Eventually, a region of complete blindness is reached.

The blind spot is mapped by having the observer report the points at which a small object — for example, a white spot on a black background — disappears and then reappears as it is moved in various directions from the center of the visual field toward the periphery. You can easily demonstrate the existence of the blind spot for yourself, using Figure 205 and following the instructions in the legend.

205

The Blind Spot

Close your right eye and fixate the cross with your left eye, holding the book before your face at a distance of about six inches. If you see the face under these conditions, move the book slightly closer to or farther away from your eye. When the book is at an appropriate distance, there will be a complete blank where the face previously appeared.

After-images

When the eye is stimulated intensely, as by the flash of a clear hundred-watt lamp in a darkroom, one sees a positive after-image of the stimulus. In the case of the lamp, one sees the yellow filament as if it were projected on the wall. One may also see the image with his eyes closed. This positive image is due to continuation of receptor and neural processes after the stimulus has gone. It has the same color and brightness that existed when the stimulus was present. However, the positive after-image, even of an intense light, seldom lasts more than a few seconds. Most positive after-images are even more fleeting than this. In everyday life we seldom experience such after-images.

When the positive after-image of a light disappears, the negative after-image takes its place. This after-image is complementary to the stimulus in both hue and brightness. Thus, if the filament is bright yellow, the negative after-image is dark blue.

You may demonstrate negative after-images for yourself, using the colored circles in Plate V. Cover all but one circle, look at the opening in the center intently for about thirty seconds, then look at a white or gray area, or close your eyes. You will see a circle having the complementary hue. Repeat, using each of the other circles.

Negative after-images are sometimes referred to as examples of *successive contrast,* to distinguish the phenomenon from that of *simultaneous contrast,* where the external stimulus and the complementary hue coexist, but in neighboring regions of the visual field.

Simultaneous contrast

When strips of gray paper cut from the same sheet are placed each on a different-colored background, they appear tinged with the complementary color of the background. Thus, the gray on red looks greenish, that on blue, yellowish, and so forth.

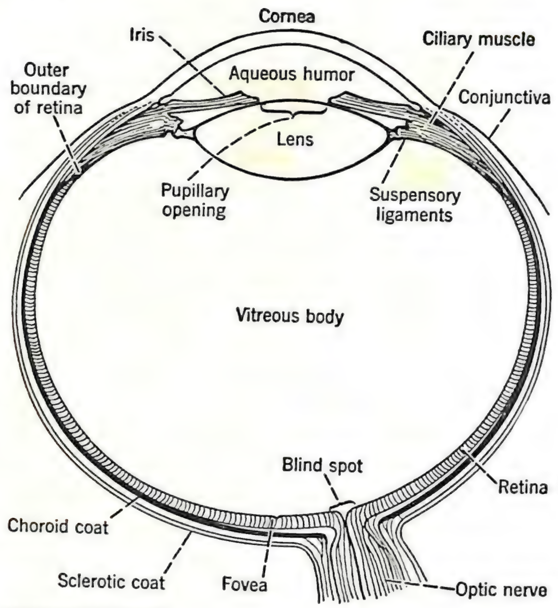
Simultaneous contrast is often used in stage lighting. Yellow light at the edge of the stage makes gray objects on the stage appear bluish and it makes blue objects appear more blue. The latter effect is similar in some respects to the effect produced by looking at a blue area after you have been fixating yellow. The blue of the after-image is, as it were, mixed with the blue before you, and this makes for a more highly saturated color.

Now that we have considered the stimuli with which visual experience is associated, and some typical phenomena of achromatic and chromatic vision, it will be enlightening to turn our attention to the structure and physiology of the eye and of related neural mechanisms. The effectiveness of light waves in arousing visual experience and visually controlled behavior depends upon their activation of these mechanisms. Likewise, the varieties of visual experience are explicable only by taking visual physiology into account.

SOME STRUCTURAL AND FUNCTIONAL CORRELATIONS

The millions of light-sensitive cells which actually receive and convert radiant energy into nerve impulses lie spread out in the thin inner coat of the eyeball known as the *retina.* In order to perceive the shapes of objects it is necessary that an accurate image of them be cast on the retina, just as it is necessary for a good image to be focused on the film in a camera if we are to obtain a clear picture. Indeed, as we examine the structure of the eye we note many obvious similarities between its structures and those of a camera. There is a light-tight "box" with a sensitive "film" at the back and an aperture at the front fitted with a lens system which can be adjusted to bring to a focus objects at various distances. One dissimilarity is that a focus is achieved in the camera by moving the lens forward and back while the eye performs this function by altering the power of the lens. This it does by changing the curvature of the lens surfaces. The image on the retina, like that on the film of a camera, is inverted. When a special system of lenses inverts the image before it reaches the eye, it appears on the retina right side up. Then the world is seen as upside down.[5]

A diagrammatic representation of the eye appears in Figure 206. At the very front is a tough, glassy coat known as the *cornea.* This is curved and acts as one of the principal refracting surfaces in the lens system of the eye. Small imperfections in the cornea, as when its curvature in one direction is different from its curvature in another, result in the condition known as astigmatism. This can often be corrected by the use of glasses ground to compensate for the imperfections. The *lens* proper is located a bit farther back in the eye. Between it and the cornea is a chamber filled with a fluid, the *aqueous humor.* The lens, composed of a resilient material, is held in place by *suspensory ligaments* attached to its edge. These ligaments exert a tension which tends to flatten the lens. But this tension is reduced when the ciliary muscle contracts. The lens has a natural elasticity so that, when tension from the suspensory ligament is relaxed, it bulges. Thus the ciliary muscle controls the curvature of the lens reflexly, adjusting it at its best focus for the distance of the object which is being examined. This adjustment is called *accommodation.* When people grow older the lens loses some of its resilience. This, of course, reduces its range of accommodation. However, the defect may



206 **A Cross-Section of the Human Eye**

When we look directly at (fixate) an object, its image is centered upon the fovea. Vision outside of the fovea is referred to as peripheral vision.

be corrected by fitting the eye with bifocals, glasses which have a "strong" section, for viewing near objects and a "weaker" section for more distant vision. The minor adjustments within these ranges can still be made by the eye. Sometimes even in the young, the focal range of the whole lens system is not correctly adjusted to the length of the eyeball. This might occur either through excessive curvature of the cornea or through the possession of an eye of abnormal depth. If the individual is unable to accommodate for near objects we say that he is far-sighted. If his failure is for the more distant ranges he is said to be near-sighted. These conditions may normally be corrected by the use of properly selected glasses.

Just in front of the lens is the *iris,* with its opening, the *pupil.* The iris serves the same function as the diaphragm in a camera. When stimulation by light is intense, the fibers of the iris dilate and the pupil becomes quite small. In low illumination the fibers of the iris contract, causing the pupil to become quite large.

The main chamber of the eye is filled with a jelly-like substance, the *vitreous humor.* The walls of the eyeball comprise: (1) an outer *sclerotic* coat, which is a tough covering, continuous with the cornea at the front; (2) an intermediate *choroid* coat, which is heavily pigmented and serves to make the wall of the eye reasonably impervious to light; and (3) an inner coat, consisting of the sense cells and their associated nerve tissue, the *retina.*

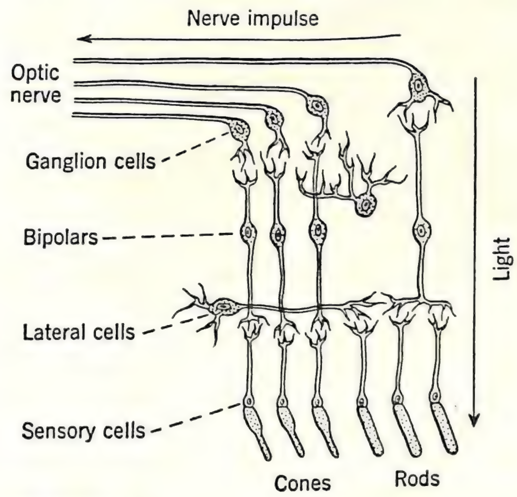
The retinal layer is actually an extension of the brain, derived from tissues which grow outward from the brain during embryonic development. It is a highly complicated structure the receptors of which are modified neurons. These receptors, the *rods* and *cones,* are illustrated schematically in Figure 207. The region of clearest vision in the eye, the *fovea,* is a small depression packed tightly with receptors which are apparently all cones. It is on this region that light rays normally focus when we look directly at an object. The fovea is relatively free of blood vessels and connective tissues. This, together with the presence of millions of cones, accounts for the great detail that is evident in foveal vision. Each cone appears to have its own "private line" to the brain. Outside of the fovea, where there are both rods and cones, it is characteristic for fibers from several receptors to converge upon a single *ganglion cell.* Rods are characteristically linked several to a ganglion cell. In the outer regions of the retina, rods alone are found.

The axons of ganglion cells, traversing the retina, come together to form the *optic nerve* and to carry the eye's messages to the brain. Between the visual receptors and ganglion cells are intervening nerve cells. Some of these provide pathways leading in a direct line from the individual sense cell

to the nearest ganglion cell. Others make lateral connections within the retina. These lateral pathways (Figure 207) are absent in the fovea. Their function is not clearly understood.

The optic nerve emerges from the eye a few degrees nasally from the fovea. It is here that we have a blind spot, as already indicated (p. 428).

Before discussing how retinal impulses reach the brain, thus eliciting vision, we pause to consider some functions of the cones and rods as well as certain theories concerning the former.



207 **The Human Retina**

The rods and cones face away from the front of the eye and, as indicated by the arrow, light must pass through the neural elements of the retina in order to stimulate them. When it reaches a layer of pigment in close proximity to the rods and cones it stimulates their tips, thus arousing nerve impulses. (After Bartley, S. H., "Some Factors in Brightness Discrimination." Psychol. Rev., *1939, vol. 46, p. 347.)*

Cones

Cones are necessary for color vision, but they also function in achromatic vision at daylight intensities of illumination. Animals whose retinas lack cones are color blind. Human color blindness is usually attributed to some defect in the cones or in their neural connections. The reason that we fail to see hues in twilight is that the cones do not function under low illumination.

The cones, as we have already suggested, are most thickly concentrated in the fovea, which contains no rods. As the periphery of the retina is approached, cones decrease in number, but the rods increase. Outside of the yellow-blue zone of the retina, as measured under high illumination, there are probably few, if any, cones. The entire retina is believed to have around seven million cones.

The cones and color theory. While it is definitely established that the cones mediate color vision, very little is known about how they do it. There are many theories, each attempting to explain color phenomena in terms of activities within the cones, within the nervous system, or within both. None of the theories accounts for all the phenomena of color vision, and at the same time conforms with the facts of physiology and neurology.

The simplest tenable theory of color vision supposes that there are three types of cones, and that these, while overlapping considerably in their range of wave-length sensitivity, have their peaks of sensitivity at the red, green and blue regions of the spectrum. This supposition is supported fairly well by the facts of color mixture. By shining red, green and blue lights in various combinations and proportions onto a white screen (or through it, as in Figure 203), we are able to produce any hue in the spectrum. By mixing all three at once, we can produce white. Yellow, as we have seen, can be obtained by mixing red and green light.

This three-component theory of color vision was propounded in 1801 by Thomas Young. It was further developed by Ludwig

von Helmholtz, hence it is today known as the Young-Helmholtz theory. It not only accounts for mixture of wave lengths, but also for negative after-images. These are assumed to arise from differential stimulation of the three types of cones. For example, wave lengths in the red region maximally stimulate the red cones, but leave the blue and green cones relatively unaffected. The red cones are then fatigued, and the other cones not. Stimulation with achromatic light (as when we look at a white or gray surface) now activates the blue and green cones more than the red. What we have, in effect, is the resultant of a mixture of blue and green, or white minus red — i.e., blue-green. Other negative after-images are similarly explained. Yellow appears after stimulation with blue because it corresponds with a mixture of red and green, or white minus blue. Certain other aspects of color vision are not readily explained by the Young-Helmholtz theory, and some modification may need to be made. Nevertheless, it is the theory most generally accepted today by physicists, physiologists and psychologists.

Color theory stresses the differential functioning of cones. However, nerve impulses set up by cones must be transmitted to the brain before color vision occurs. Everything that we know about the nerve impulse suggests that these impulses are alike, no matter what wave length of light and what type of cone are involved. This means that the brain itself, probably the occipital cortex, must react differentially to the impulses originating in different cones. It has been suggested that impulses from different kinds of cones go to different places in the occipital lobe. There is as yet no direct evidence of such a difference in locus for impulses from different types of cones. If such a difference occurred, it could perhaps help us to explain why, even though the impulses aroused by different wave lengths and originating in different kinds of cones are similar they give rise to different color experiences.[6]

Rods

It has been calculated that the retina contains over one hundred million rods. There are, as we have seen, no rods in the fovea and there are relatively few immediately surrounding it. Rods increase in number as the periphery of the retina is approached.

Rod vision is solely achromatic. If you slowly decrease the illumination on the spectrum in Plate I, the sensitivity of your cones will gradually decrease and, when a sufficiently low illumination is reached, all hues will disappear, leaving only a series of grays. This is the point at which your cones stop functioning. At a still lower illumination, the fovea, containing cones only, becomes blind. Then you can see only with the peripheral retina — out of the "corner of your eye." Under conditions of light-adaptation, your cones are highly sensitive, but under conditions of dark-adaptation they become completely insensitive. Your vision is then purely peripheral, and purely rod vision. Under these circumstances brightness, but not hue, is perceptible. This shift from cone to rod vision is responsible for the shift in wave-length sensitivity which we have already (p. 421) discussed as the Purkinje phenomenon.

The increased sensitivity to light as a result of dark-adaptation is due to changes which take place in the rods. That dark-adaptation is a function of the rods rather than the brain is shown by the fact that one eye can be dark-adapted while the other is being light-adapted.

While the eye is in darkness there is increasing concentration of a photochemical substance in the rods. Because it has a purplish color, this substance is referred to as *visual purple*. The technical term for it is *rhodopsin*.

Visual purple. When the visual purple is removed from the rods of animals under dim red light (which does not stimulate the rods), it retains its purplish color. Subjecting

it to light bleaches it until it has a yellowish appearance. The bleaching effect is similar to that involved in stimulation of a photographic plate by light, and the same formula applies. The reaction of visual purple to light is thus photochemical.[7]

When visual purple is outside the eye, it fails to regain its color after stimulation. In the eye, however, bleaching is followed by recovery, for the purplish color is regained during dark-adaptation.

The cycle of events from stimulation to recovery in darkness is believed to be somewhat as follows: visual purple (rhodopsin) is decomposed by light to form a yellowish substance (retinene). This part of the process is photochemical. The yellowish substance eventually decomposes to form vitamin A and proteins. Vitamin A and the proteins then synthesize, under conditions of darkness, to produce visual purple.[8]

Vitamin A and night blindness. Some human beings do not readily become dark-adapted. These people are blind under conditions of very low illumination, such as exist at night.

Night blindness was recognized by the ancient Egyptians, who used liver, preferably raw, as a remedy. We now know that the defect is caused by insufficient vitamin A and that liver is a rich source of this vitamin. It is also found in certain fruits and vegetables.

Army and Navy personnel who must see well at night are fed a diet rich in vitamin A. This enables them to adapt readily to the low night illumination. Sometimes the diet is supplemented with doses of vitamin A. You should not assume, however, that a person with no vitamin A deficiency will see better at night by taking additional amounts of vitamin A.

It takes about forty minutes to become completely dark-adapted, yet this adaptation is lost within a few minutes when one looks at brightly illuminated objects, like charts and instrument boards. How, then, can one who must look at charts, instrument boards, and the like, keep his dark-adaptation so that he can also respond readily to objects with low illumination? One solution is to use red light, which has only a negligible effect on the dark-adapted rods. The most convenient way to keep dark-adapted while at the same time carrying on activities which require response to illuminated objects is to wear special tight-fitting red goggles. Since the goggles admit only red light, the rods do not lose their adaptation. One takes the goggles off when he steps out into the darkness and puts them on again before he goes into the light. When such goggles are used, charts must be drawn in other colors than red, for red markings cannot be distinguished through red filters.[9]

Visual acuity

The closer two impressions may be on your retina, and still be seen as two, the greater your visual acuity. As intensity of illumination increases, acuity also increases. For example, observe the objects in Figure 208 under different intensities of illumination, but keeping the figure at a constant distance, say, six feet, from the eye. You will observe that the smallest visible separation decreases as the intensity of illumination increases. Acuity is poorest under low illumination, when the rods alone are functioning. Under conditions of constant illumination, it becomes poorer as the periphery of the retina is approached. For example, fixate an object to the side of Figure 208 and look at the latter "out of the corner of your eye." You will observe that a larger separation must now occur in order to be visible. Given good illumination, acuity is at its maximum in the fovea — that is to say, in direct vision.

These facts concerning visual acuity closely conform with what is known about the retinal distribution of rods and cones, and about the neural connections of each.

208

A Test of Visual Acuity

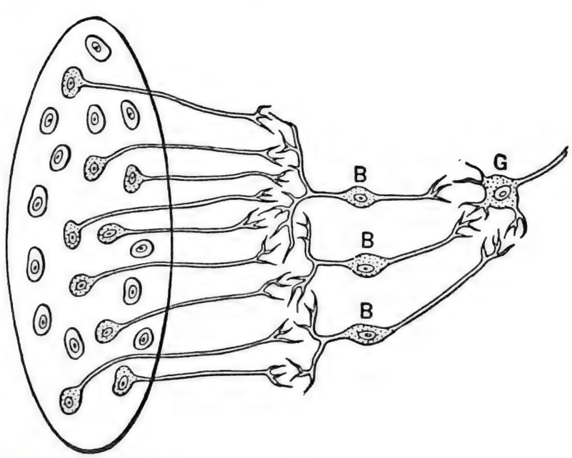
Your acuity is greater the smaller separation you can see at a specified distance and with a specified intensity of illumination. The ability to observe a small separation of objects on the retina depends on the lens and refractive media of your eye, but it also depends on the separation of receptive fields in the retina. This is a part of the Landoldt broken ring test.

The fovea, as we have already seen, is thickly populated with cones, but contains no rods. Two impressions could here be brought very close together, yet stimulate separate receptor cells.

Rods converge upon the bipolar cells and optic ganglia in the manner represented in Figure 209. The retinal field thus served by a particular ganglion is referred to as the *receptor field.* Stimulation anywhere within this field would produce a response in the same ganglion cell. Two separate points or lines, to be seen as two, would thus need to fall each in a different receptor field. This is another reason for the poorer acuity of the periphery than of the fovea.[10]

Flicker

When a light flashes on and off at a sufficiently slow rate, we see the separate flashes. As the flash rate is speeded up — that is, the interval between flashes shortened — a frequency is reached where separate flashes are no longer evident. Flicker occurs. With a further increase in the frequency of flashes, a stage is eventually reached where it appears that we are stimulated by a constant light. The separate flashes of your sixty-cycle electric light are seen neither as separate nor as flicker. It appears that the light is constant. The fre-



209

The Receptive Field of a Single Optic Nerve Fiber

The large circle in perspective is the surface of the retina. The small circles within it are receptor units. Fibers from these go to the bipolar cells, B. *The bipolars themselves converge on the ganglion cell,* G, *the fiber of which carries the nerve impulse to the thalamus. (After Bartley, S. H.,* Vision. *New York: Van Nostrand, 1941, p. 78.)*

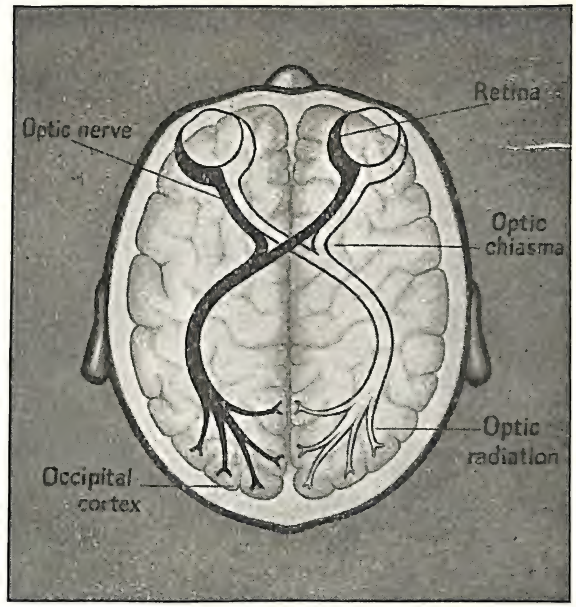
quency of flashes required to produce such a fusion is known as the *critical flicker frequency*, or *c.f.f.* This frequency is a function, among other things, of light intensity. It is low with a low light intensity and high with a high light intensity. The critical flicker frequency differs somewhat from one person to another and this difference is now known to be related to circulatory and other physiological conditions of the individual.

Retinal interaction

The critical flicker frequency has been used as an index of neural interaction within the retina. As we have already suggested, the retina is an intricate mechanism comprising not only the rods and cones, but also lateral neurons, bipolar cells, ganglion cells and other neural structures. The foveal region, with its cones, each connected by a "private wire" to the brain, shows no evidence of interaction between one unit and another. Whatever interaction occurs must take place in the brain. But the rods are so interconnected that some sort of interaction at a retinal level is to be expected. Several experiments have shown, in fact, that the effects of stimulating different groups of rods summate (p. 47) so as to produce results different from those obtained with one group alone. For example, four small flashing disks on the peripheral retina had a c.f.f. which was 2.5 flashes per second higher than when only one flashing disk of the same intensity was used. The effect was as if there had been an increased intensity of stimulation. In the fovea, one or four disks had approximately the same c.f.f., showing that here there was no summation.[11]

The pathway from eye to brain

Observe in Figure 210 that fibers from the right half of each eye go to the right side of the brain and that fibers from the left half of each eye go to the left side of the brain. Thus, if your right optic pathway were severed between the optic chiasma and the brain, you would be blind in the right half of each eye. If the optic chiasma were cut where the fibers cross, you would be blind in the nasal region of both eyes.



210 **Route of the Optic Fibers to the Brain**

In this schematic drawing, the optic fibers appear as if seen through the brain matter from above. The fibers shown in solid black represent those mediating vision in the left half of each eye; those in white, the right half of each eye.

The optic fibers terminate in various structures in and around the thalamus. They then make synaptic connection with fibers which carry them to the occipital lobe. There are actually four essential links in the pathway from eye to brain. First, there is the rod or cone. Second, there is the bipolar neuron. Third, there is the neuron running from ganglion cell to thalamus. Finally, there is the neuron connecting thalamus and occipital cortex.

If optic connections in your right thalamus

were destroyed, you would be blind in the right half of each eye, regardless of the condition of your eyes as such. A comparable blindness would be produced by destruction of the right occipital lobe.

Some of the connections made in and around the thalamus are motor, since their function is to mediate control of the ciliary muscle which, as you will recall, regulates the curvature of the lens. Other near-by connections serve in control of head and eye movements associated with vision. Many fibers from the optic nerves make connections in the thalamus with fibers running to the occipital cortex in what is known as the *optic radiation* (also see Figure 28, p. 60).

You will recall, from our earlier discussion of thalamic and cortical functions (p. 57), that some sensory functions in animals do not require the cortical connections. They are mediated at a thalamic level. Even detailed vision, such as that involved in discriminating between triangles and circles, is found in decerebrate birds. In man, however, all visual functions require cortical connections. As suggested above and in the earlier discussion of cortical functions, man is completely blind when both occipital lobes are removed. When the occipital lobe on only one side is destroyed, he is blind in the corresponding half of each eye.

How our visual cortex contributes to the various visual phenomena discussed in this chapter is not known. But, as we suggested earlier (p. 432), color vision seems to depend upon impulses from different types of cones terminating in different parts of the brain. There is evidence that yellow is produced by a response of the brain to impulses coming in from red and green receptors. There is a suggestion that brightness depends on the number of nerve impulses per second reaching the occipital cortex, but here again further research is necessary before such a possibility is either established or refuted. So far, the most revealing research on structural and functional correlations in vision has dealt with the eye itself, and especially with the retina.

VISUAL SPACE PERCEPTION

The apparent size, position, distance, and depth of objects which reflect light onto the retina are judged in terms of a variety of cues, some physiological and some psychological. Sometimes, as illustrated in Figure 211, the various bases of judgment combine so as to deceive us. The room seems to be of normal shape, while the man and child are distorted in size. If one of these is normal, it seems, the other must be abnormal. In reality (see p. 609), the room itself is greatly distorted. In this section we consider some of the bases of such perceptions.

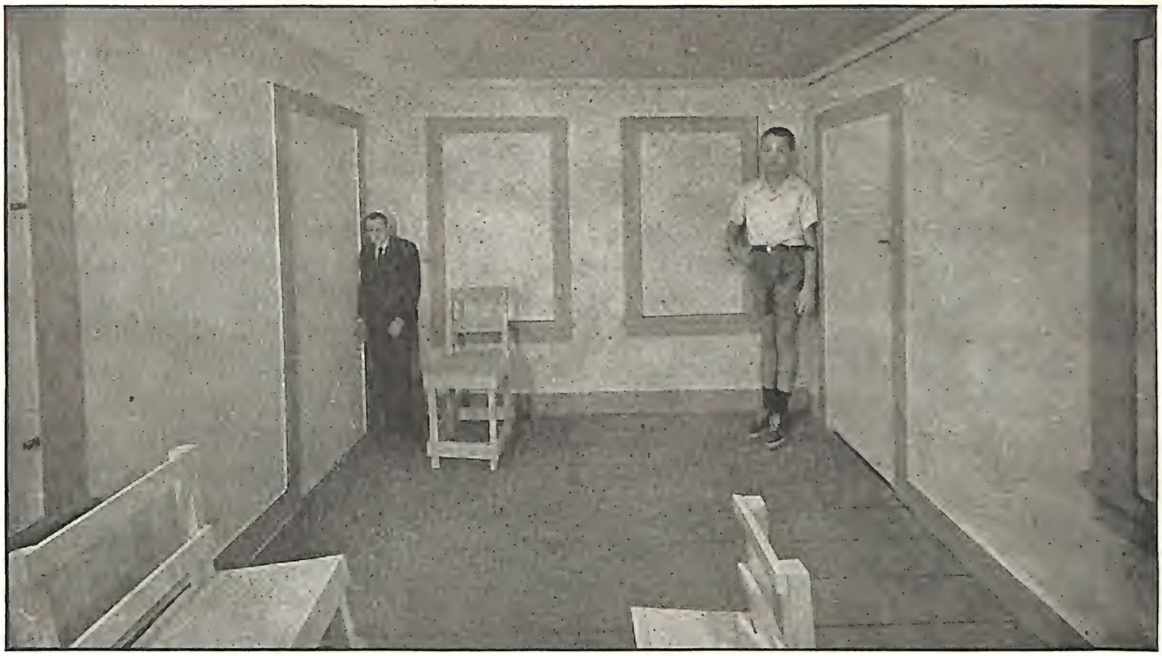
Size

We judge the size of objects in terms of the magnitude of their retinal representation, their relation to other objects, and what we already know about them. Within certain limits, as indicated earlier (p. 408), the apparent size of an object remains constant. Beyond these limits, its size seems to vary with that of the retinal image. But the relation of this object to others is also important. If you see a picture of a fishhook, for example, you do not know whether it is a large or small one until you see it alongside of some familiar object, like a finger or a pencil. Thus context is an important factor in judgment of size.

Depth and distance

The retinal image, unless very small, is curved to conform to the curvature of the eye-ball. But this curvature is of the same nature as the curvature that we might impose upon a photo by bending it. It involves no real depth.

If there is no depth in the retinal image of objects at different distances from the eye,



211

How Our Eyes Can Deceive Us

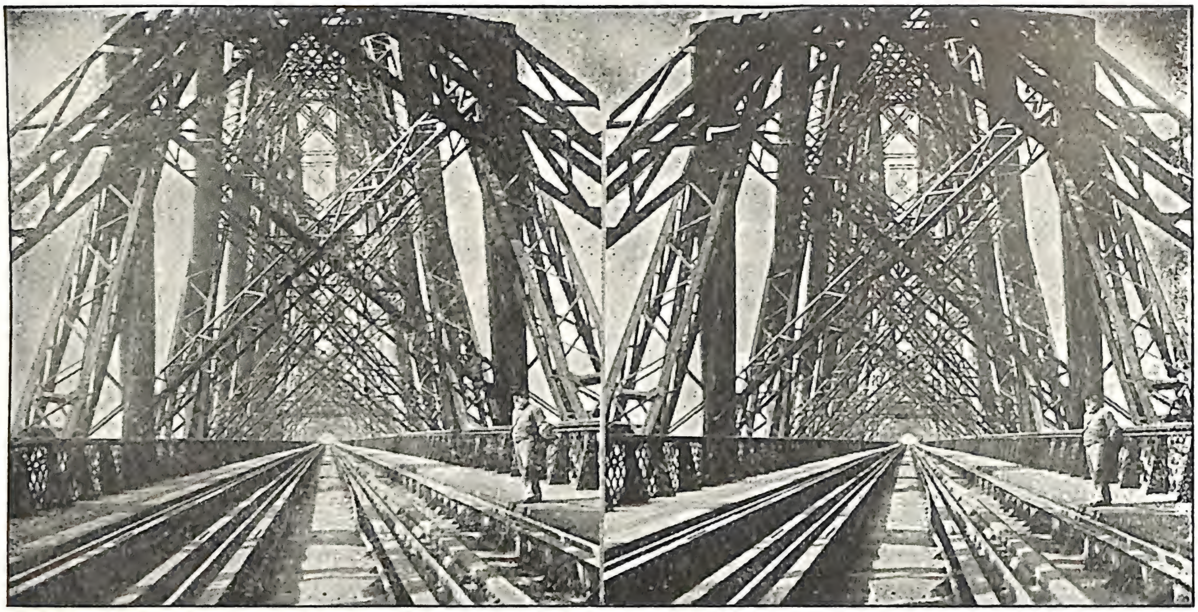
When the man and the boy change places the man looks very large and the boy looks very small. The room (see one like it in the Appendix, p. 609) is actually very much distorted, yet it seems normal as viewed here. (Photographed for Life *by Eric Schaal.* © Time, *Inc.)*

how do we perceive the third dimension? We do so in terms of cues provided by responses of the eyes and by certain aspects of the retinal image. Some cues are *monocular,* requiring stimulation of only one eye, while others are *binocular,* requiring stimulation of both eyes. Cues to depth perception may also be classed as *physiological,* depending upon the structure and movements of the eyes, and *psychological,* depending upon our interpretation of certain aspects of the visual image itself. Some of the physiological cues are monocular and others binocular. All of the psychological cues, however, are primarily monocular.

Physiological cues

One physiological cue of distance is related to accommodation of the lens. The lens is relatively flat for fixation of distant objects. When objects are within the accommodatory range of the eye, however, the lens becomes less flat as the objects are moved closer. These changes in curvature are produced by tensions and relaxations in the ciliary muscle and suspensory ligaments (pp. 429–430). Nerve impulses aroused by such activities of muscles and ligaments are sent to the brain, where they may serve as cues of distance.

Convergence of the eyes provides a cue of distance, so long as objects are within about fifty to sixty feet. This cue occurs monocularly as well as binocularly. When the eyes converge to fixate a near-by object, the two muscles which turn the eyes inward are tensed, but those which turn them outward are relaxed. Likewise, when the eyes diverge to fixate a more distant object, the two



212

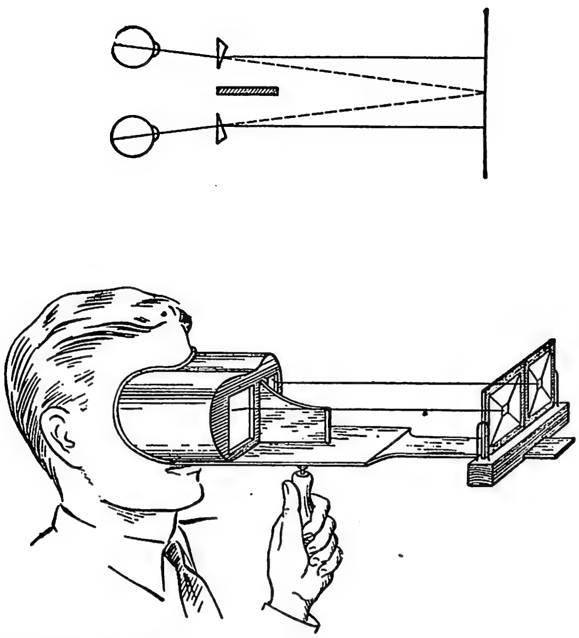
Two Pictures of the Same Situation Taken with a Stereoscopic Camera Having Lenses at Same Distance Apart as That of the Human Eyes

Comparison of the distance and angles in the two pictures will show that there are slight discrepancies. (From the Titchener series. Courtesy of C. H. Stoelting Company.)

muscles which turn them outward are tensed, and those which turn them inward relaxed. Nerve impulses aroused by such changes in muscle tension are sent to the brain, thus providing distance cues.

Each eye gets a somewhat different picture of the same object or situation. In looking at a situation such as that represented in Figure 212, for example, the right eye sees around the right side of objects a little more than does the left eye. On the other hand, the left eye sees a bit farther around to the left. This difference in the view obtained with each eye is referred to as *retinal disparity*. That it provides important cues concerning depth is well known to anybody who has viewed such pictures as the one in Figure 212 through a stereoscope.

The principle of the stereoscope is illustrated in Figure 213. Observe that the right eye sees only the picture taken with the camera on the right, and the left eye only that taken with the camera on the left. The screen prevents either eye from being stimulated in any way by the noncorresponding picture. The function of the prisms is to throw the disparate images on the same regions of the retina which would be stimulated were the original scene viewed by the two eyes under normal circumstances. The tridimensional image, produced by some fusion process in the brain, is projected, as it were, along the dotted lines. These lines are illustrated as extensions of the lines from prisms to retina. The well-known Viewmaster accomplishes the same result without use of prisms. A camera like the widely advertised Stereo-Realist takes two pictures simultaneously, one from the position of each eye. In looking through the Viewmaster or comparable viewer, we place the right-side picture over the right eye and the left-



213 **The Principle of the Stereoscope**

Observe that the prisms of the stereoscope throw the images toward the outer part of the retina, where they would fall if the object were straight ahead. The subject then sees the picture, with depth, at a point between the actual pictures, the point where the dotted lines meet. The small partition prevents the right eye from viewing the picture designed for the left eye, and the left eye from viewing the picture designed for the right eye.

side picture over the left eye, with the result that an extremely realistic depth effect is produced.

You have perhaps observed another application of the retinal disparity principle, for it is sometimes used in store-window advertising and in the moving pictures. The pictures used are printed in two colors, usually red and blue. Instead of being printed as separate pictures, however, they are superimposed. But what would be seen with the right eye is printed in red and what would be seen with the left eye in blue. You now look at the still picture, or movie, through spectacles having a red and a blue filter. The red filter over the left eye prevents you from seeing the red picture (appropriate for the right eye). Likewise, the blue filter over the right eye enables you to see the red picture but not the blue one (appropriate for the left eye). Under these conditions you observe depth, much as in a stereoscope. The result is so realistic in movies of a man pitching a ball toward the camera that most members of the audience "duck, as the ball comes toward them." It appears that the ball leaves the screen and is about to hit one between the eyes. These representations of the retinal disparity principle are known as *anaglyphs.**

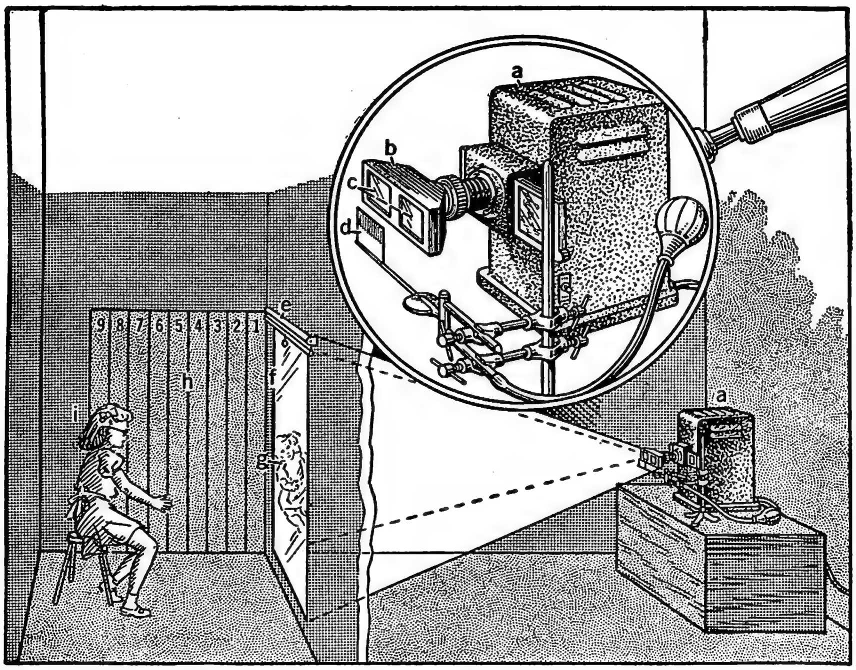
Still another example of the retinal disparity factor is illustrated in Figure 214. This is especially interesting in that it demonstrates depth perception based on retinal disparity in children as young as one year. The principle of presentation is similar to that in anaglyphs. However, light coming from the stereograms is polarized as illustrated. Polaroid lenses prevent the right eye from seeing the left eye's view and the left eye from seeing the right eye's view. The object, in this case a doll, seems to stand out from the screen. The effect is so realistic that the child reaches out and tries to grasp the doll.[12]

We have recently seen many military uses of stereoscopic principles. Stereoscopic cameras take reconnaissance pictures which make it possible to tell not only that a building stands at a particular spot, but its height, and many other characteristics. Visual range-finding instruments also make use of retinal disparity and the stereoscopic vision based on it.[13]

Psychological cues

The size of the retinal image is in itself

* Slides (2″ × 2″) and movies (8 and 16 mm) based upon this principle are obtainable from Horner-Cooley Productions, Inc., 6356 Hollywood Blvd., Hollywood 28, Calif.



214

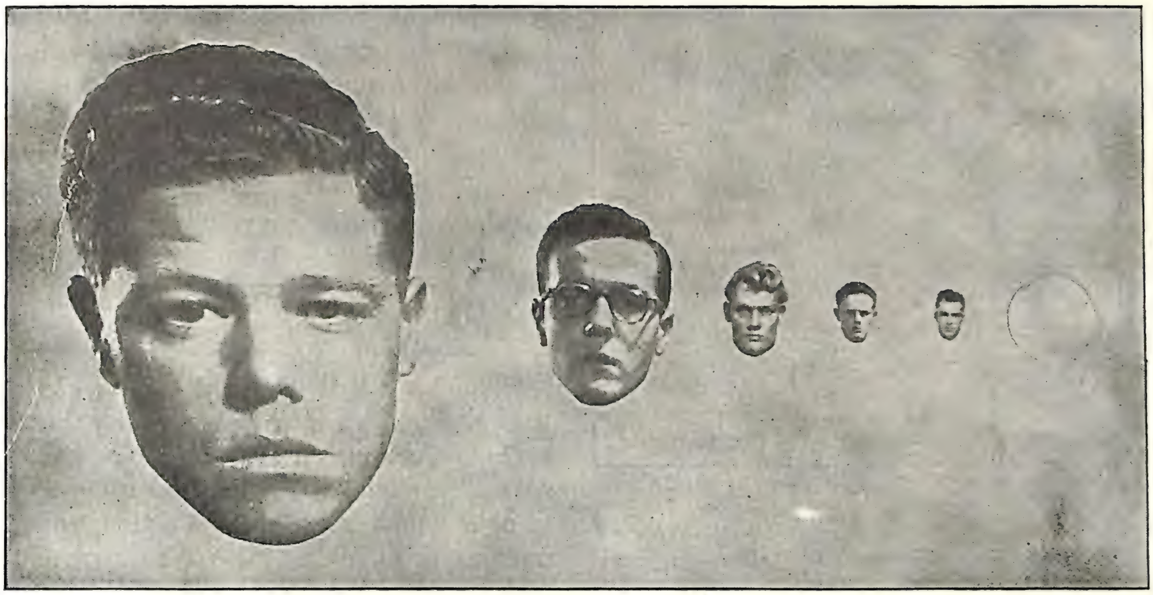
A Device for Demonstrating Depth Perception Based upon Retinal Disparity

A general discussion of this device appears in the text. The diagrammed parts are as follows: (a) *Leitz projector for showing 2″ × 2″ slides.* (b) *Steroly attachment which splits light from projector into two beams.* (c) *Polaroid screens that polarize the two beams, one vertically, the other horizontally.* (d) *Pneumatically operated blind.* (e) *Window shade.* (f) *Ground glass screen.* (g) *Polarized images thrown by projector.* (h) *Ruled cardboard indicating distances from screen,* (i) *Child viewing the polarized images through polarized spectacles. The phenomenal position of the doll is revealed by the reaching responses of the child. (After Johnson, B., and Beck, L. F., "The Development of Space Perception: Stereoscopic Vision in Preschool Children,"* Journal of Genetic Psychology, *1941, vol. 58, p. 250.)*

physiological, but its use as a clue to distance is largely a matter of interpretation. Obviously, the image becomes smaller the more distant the object. If the distance is sufficiently great, so that size constancy (p. 408) is not involved, we perceive the object as smaller, hence as more distant, when its image on the retina is smaller. The interpretative factor enters when the object seen is of a familiar size. A Flying Fortress is of constant size, hence when the image is small, we judge the plane to be a greater distance up than when the image is large. In the case of a cloud, however, this clue is of relatively little help. Clouds could be of any size. What we see might be a large cloud far up or a small cloud near the earth. Even when the image is of constant size, as in Figure 215, distance seems to vary with one's interpretation. If the object is believed to be a beach ball, we see it as farther off than if it is believed to be a ping-pong ball.

Interposition is another depth or distance cue. The object which overlaps another (Figure 216) is of course judged to be closer.

Linear perspective — the decrease in size or separation of objects as they become more distant — is often used by artists to repre-



215

An Aspect of Distance Perception

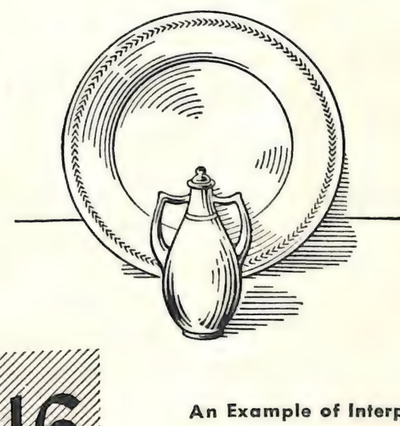
The judged size of the ball influences its apparent distance. If you look upon it as a ping-pong ball, it appears at about the same distance as the nearest face. Regarded as a beach ball, however, it seems to move back and be located across from the most distant face. (Photographed for Life *by Eric Schaal. ©* Time, *Inc.)*

sent distance. Railway lines converging as the horizon is approached (Figure 217) provide a good example. Telegraph poles, trees, and other objects of standard size also seem smaller as they recede into the distance.

When we do not know the actual distance of objects, *aerial perspective,* or clearness of details, is an important monocular cue. The tower (Figure 218), the mountain, or some other object which stands out from its surroundings, seems closer on a clear day than on a smoky or foggy one. Any unfamiliar object seems closer if we can make out its details. This is exemplified every time we use binoculars or a telescope.

Shadows also provide cues of depth. Note in Figure 219, for example, that the impression of depth may actually be reversed if the picture is turned upside down, thus making the shadows slope in the opposite direction.

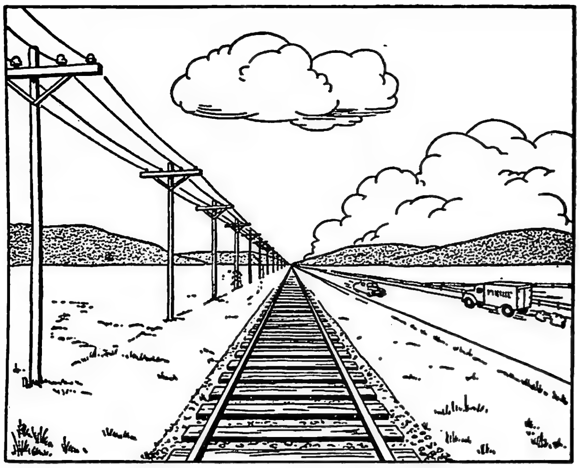
The *relative movement* of objects is sometimes important in judging distance. Other things being equal, the object that seems to move by us rapidly is judged to be closer than that which moves by slowly. Moreover, if we ourselves are moving, objects nearby



216

An Example of Interposition

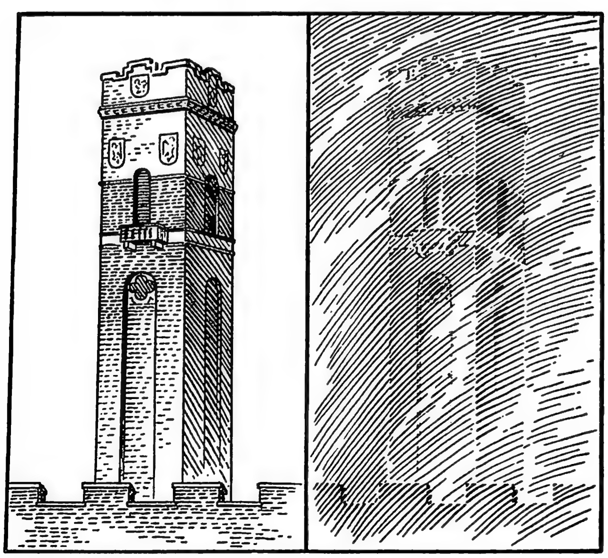
An object which obscures any or all of another object must be closer.



217 **An Illustration of Linear Perspective**

seem to go past in the opposite direction to that in which we are traveling, but distant objects appear to move with us. There is evidence that individuals with only one eye depend upon clues derived from head and eye movements as well as movements in the environment. This is especially true for judgment of near distance, as when returning a spoon to a sugar bowl.

Some movie cartoons utilize a combination of these psychological cues to give a very realistic impression that one is viewing depth.



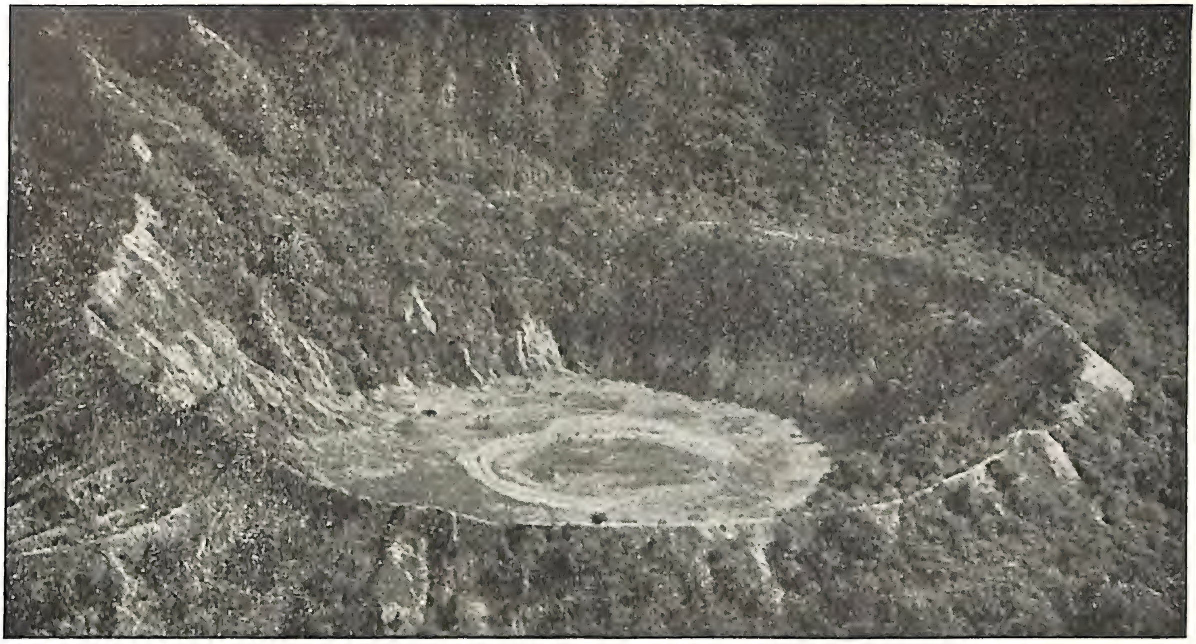
218 **An Illustration of Aerial Perspective**

SUMMARY

What we see is dependent upon (1) the light transmitted to our eyes, either directly or by reflection, (2) the physiological and neural reactions of the eye and optic cortex to light which falls upon the retina, and (3) our interpretation of these reactions, which of course involves non-visual as well as visual regions of the brain. The appearance of abstracted (aperture or film) colors corresponds more closely with what we know about the stimulus aspects of color than does the appearance of objects or surfaces, i.e., surface colors. The apparent intensity of surface colors, both achromatic and chromatic, is referred to as their *lightness*. *Brightness* is used to refer more specifically to the apparent intensity of aperture colors.

Chromatic vision varies *in hue* and *saturation*, as well as in brightness (or lightness). Hue is what we commonly call "color," for example, red and green. It is correlated rather closely with the wave length of light. Saturation refers to the amount of color, for example, a red (American Beauty) rose has a high saturation; a pink carnation a low saturation. Saturation is correlated with the complexity of light waves. Monochromatic light (a narrow band of wave lengths) has the highest saturation. The discussions of color vision in this chapter apply most directly to aperture colors.

Brightness differences are often represented by the white-black continuum, a series ranging, by discriminable stages, from white to black with neutral gray at the midpoint. Color differences are often repre-



219

The Influence of Shadows on Depth Perception

This is a volcano crater in Rabaul. Turn it upside down, however, and a mound instead of a crater is seen. Life *once printed a picture of the moon inverted, in which the craters appeared to be mounds. (Photo from Whites Aviation, Ltd.)*

sented by a color circle. The spectrum is bent, as it were, to form a circle, but with purple, a nonspectral color obtained by mixture of red and blue or violet, bridging the gap between red and violet. The black-white continuum and color circle are combined in the color solid, one form of which is a double cone. Brightness is represented in this solid as varying from white at one end of the vertical axis to black at the other. Neutral gray takes the intermediate position. This position is the level of the color circle, or base of the two cones. Hues are represented here as at their greatest saturation, or purity. This represents the fact that the most highly saturated colors are of intermediate brightness. As brightness increases or decreases, the color is represented as having shifted above or below the brightness midpoint, and thus as having moved inward toward the vertical axis of the figure.

The laws of color mixture were illustrated by reference to retinal color mixture, where overlapping disks are rotated so that the retina is stimulated successively by two or more colors. Mixture of complementary hues (such as red and blue-green, yellow and blue) produces neutral (or achromatic) colors. All colors and gray may be obtained by mixing red, blue-green, yellow and blue in appropriate combinations. Stimulation with red and green light under certain conditions produces yellow. Binocular mixture of red and green demonstrates that yellow, under these conditions, is a product of brain processes.

Among the phenomena of color vision discussed were: color blindness, and especially red-green blindness; retinal color zones, the loss of red-green vision in the periphery of the eye where blue and yellow are still visible; negative after-images, the images of complementary color which are aroused after a color stimulus is removed; and simultaneous contrast, the tendency for objects in the neighborhood of a color to assume the complementary hue.

Much of our detailed discussion of structural and functional correlations dealt with the retina. This is an outgrowth from the brain and it contains a highly complicated arrangement of receptor cells and neural connections. The receptor cells are known as rods and cones.

Rods mediate achromatic vision and make vision under conditions of low illumination possible. They contain a light-sensitive substance known as visual purple. This substance bleaches when exposed to light and recovers its purplish color in darkness. The properties of visual purple, and especially its ability to regenerate in darkness, are dependent upon vitamin A. Deficiency of this vitamin produces night blindness.

Chromatic vision is dependent upon the cones. There are probably at least three kinds of cones, mediating red, green, and blue vision. Whether or not there is another type mediating yellow is problematical, for yellow can be obtained by mixing red and green. Cones cease to function under very low illumination; that is why all objects lose their hues in twilight. Under such conditions, only the rods, which have no chromatic functions, are activated. As twilight approaches, the yellow-red region of the spectrum, the brightest in daylight, becomes relatively less bright. On the other hand, the blue-green region, not very bright under daylight conditions, becomes the brightest region. This shift in the brightness values of the yellow-red and blue-green regions is known as the Purkinje phenomenon. It is explained by the differential sensitivity of cones and rods to portions of the spectrum, and to the dropping-out of cone vision as darkness comes on.

The fovea contains only cones. These are packed tightly together and have relatively few interconnections at lower levels of the retina. The visual acuity of the fovea — its differentiation of fine details, such as separation of two points, or lines close together — depends upon the large number of closely packed cones that it contains, and upon the many cones that have individual connections with optic nerve ganglia. The poorer acuity of the peripheral retina is partly due to the fact that it contains few cones. Its receptor cells are primarily rods, and many of these converge on a common ganglion. Thus, in order to stimulate two separate receptor fields, stimuli must be relatively far apart on the peripheral retina.

Flicker is produced by alternating light flashes. The frequency at which these flashes fuse to give an impression of steady light is the critical flicker frequency (c.f.f.). This frequency becomes higher as light intensity increases. The c.f.f. has been utilized in research on retinal interaction, which is a function of rods and their neural interconnections. The results show that neural summation occurs in the retina as well as in parts of the central nervous system.

In going from retina to brain, one half of the optic fibers cross to the opposite side. The right half of each retina sends impulses to the right side of the brain, and the left half of each retina to the left side of the brain. The thalamus is a way station on the route from retina to brain. In animals lower than man, some of the simpler visual functions are carried on at the thalamic level. In man, however, impulses must reach the occipital cortex before vision, even of the simplest kind, occurs. The role of the occipital cortex in mediating color and brightness vision is not known, although it has been suggested that brightness depends on

the frequency of nerve impulses, and color vision upon the place in the cortex at which impulses from three (or possibly four) different kinds of cones terminate.

Although the image on our retina does not have depth, it contains certain cues which enable us to discern depth and distance. Some of these cues are monocular, requiring only one eye, while others are binocular, requiring both eyes. Some of these cues are physiological. The most outstanding of them are accommodation of the lens (monocular), convergence (monocular and binocular), and retinal disparity (binocular). The importance of retinal disparity is illustrated by the stereoscope and anaglyph, where two slightly different pictures, taken with lenses separated by the same distance as the eyes, are fused to produce a tridimensional effect simulating what we see with both eyes. Whether or not the use of retinal disparity as a cue of depth is innate, it at least occurs very early. This is shown by experiments on children as young as one year.

Certain other cues of depth are not related to special structures or functions such as characterize the physiological cues. Moreover, they definitely depend upon past experience for their interpretation. For these reasons, they are referred to as psychological cues. Important among such cues are the following, all of which are monocular: relative size, interposition, linear perspective, aerial perspective or clearness of detail, shadows, and relative movement.

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19 HEARING

Hearing and Sound Waves • Some Physical and Auditory Correlates: Frequency and pitch; the range of hearing; loudness and the amplitude of sound waves; timbre and the complexity of sound waves • Some Other Auditory Phenomena: Beats; combination tones; masking • Some Structural and Functional Correlates of Hearing: Auditory mechanisms; the Wever-Bray effect • Theories of Hearing: Place theory; frequency theory; the volley theory • Auditory Space Perception: Distance; direction; auditory perspective • Summary

NEXT TO VISION, hearing is our most important sense. It is especially important for the development of language and for communication with others. Like vision it is a distance sense, serving to inform us concerning things not actually in contact with the body. Even better than vision, at times, it warns of approaching danger. Like vision, hearing is also a medium for artistic expression and aesthetic enjoyment. Music can be "enjoyed" by the deaf, but only through tactual vibrations. The psychologist is especially interested in differentiating the various characteristics of what we hear and in discovering their correlates in the physical world and in sensory and neural activity.

The most evident characteristics of hearing are pitch, loudness, and timbre. *Pitch* refers to the lowness or highness of a sound; *loudness* to its strength or weakness; and *timbre* to its characteristic quality. Even when different instruments produce a note of the same pitch and loudness, the total effect is different. The 'cello, for example, produces a rich, mellow sound, but the French horn produces one that is blaring. These are differences in timbre. Some other characteristics of audition are: *volume* (low tones seem to pervade a large amount of space while high tones seem restricted spatially); *density* (some tones seem more compact than others, and this compactness varies with pitch and loudness in a manner different from volume); *brightness* (some tones seem bright and others dull); and *vocality* (some pitches sound like vowels). Vocality is utilized in the so-called "Voder" to produce electronically something which simulates speech.

HEARING AND SOUND WAVES

Differences in pitch, loudness, and timbre are produced by changing certain characteristics of sound waves. However, there is by no means a simple one-to-one relationship between isolated characteristics of sound waves and particular aspects of auditory experience. This will become apparent as we discuss the physical correlates of pitch, loudness, and timbre.

Although light travels through a vacuum, sound requires an elastic medium like air, water, bone, or metal. This is neatly demonstrated by placing a bell, with electrical connections intact, under a bell jar and then withdrawing all air from the jar. As long as air remains in the jar, the bell can be heard ringing. When all air is withdrawn, however, the bell continues to operate, but without being heard.

Under ordinary circumstances, the waves

set up by a vibrating body are transmitted through air to the eardrum. There they arouse certain mechanical activities which stimulate nerve fibers. When the impulses thus elicited get to the brain, we hear.

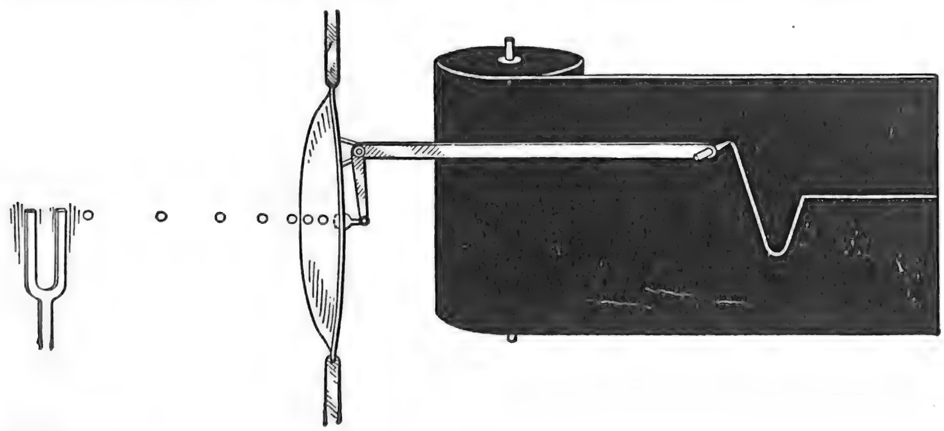
As the prongs of a tuning fork move apart, they compress neighboring air molecules and a condensation moves outward. As the prongs swing back, however, air molecules in the neighborhood become less condensed. Thus, a rarefaction occurs and moves outward. There is a condensation for every outward movement of the prongs and a rarefaction for every inward movement. Condensation corresponds with the maximum separation, and rarefaction with the minimum separation of the prongs.

With every condensation there is a maximal inward movement of the eardrum for that particular vibration. With every rarefaction, on the other hand, there is a maximal outward movement of the eardrum for that vibration.

If a diaphragm like that illustrated in Figure 220 is substituted for the eardrum, the condensations cause it to move inward and the rarefactions to move outward. An electrical and optical device represented schematically by the lever system in the diagram causes a beam of light to move up and down on a moving photographic film. The beam moves upward with a condensation, and downward with a rarefaction, of the air molecules. When the fork is at rest, the beam of light is exactly halfway between the extreme up-and-down positions. If the film on which the beam is projected is moved to the right at a constant rate while the tuning fork is vibrating, a regular succession of waves like that illustrated appears. Any such regular succession is said to be *periodic.*

SOME PHYSICAL AND AUDITORY CORRELATES

Tone is correlated with periodic vibrations; noise, with aperiodic vibrations. That is to say, vibrations that are irregular in their succession give rise to noise. The boom of a



220

A Schematic Representation of the Oscillograph

A condensation striking the diaphragm is seen. Observe that the recording point (actually a beam of light in the oscillograph) is at the uppermost position. When the recording point returns to the intermediate position (which traces a straight line when the apparatus is not activated) a double vibration, or cycle, will have been traced on the record. (Modified from an illustration which appears in the Encyclopaedia Britannica film, "Sound Waves and Their Sources.")

cannon, the hiss of escaping steam, the rustle of leaves, and the clatter of a typewriter are called noises because they produce a heterogeneous effect with no regularity and to which no definite pitch can be assigned.

Most of what we hear involves noise as well as tone. At the same time as it is producing tone, a whistle, a violin, a piano, or any other instrument may emit a certain amount of noise. On the other hand, although no definite pitch can be assigned to it, even a noise may be high, medium, or low-pitched. The noise made by jingling keys is high-pitched, but the boom of a cannon is low-pitched. Thus, there is no clear-cut separation of tones and noises. What we experience is sound in which noise predominates (noise) and sound in which tone predominates (tone).

Frequency and pitch

Tuning forks and other vibrating instruments differ in the number of complete waves or cycles produced each second. They differ, that is, in the frequency of the condensation-rarefaction cycle. One tuning fork is thus spoken of as having a frequency of 256 cycles per second, and another as having a frequency of 1024 cycles per second. As the frequency increases, the number of waves on the oscillograph are crowded closer together.

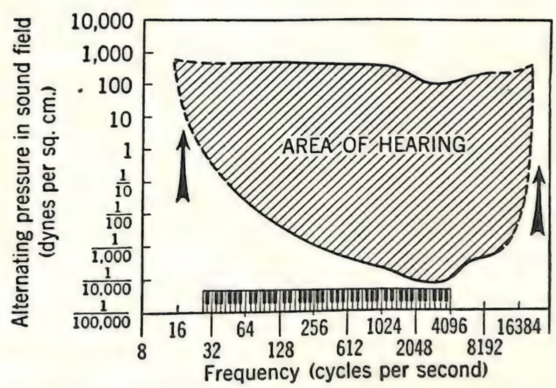
Frequency is the chief physical correlate of pitch. Pitch rises and falls as frequency increases and decreases. This is true so long as the change from one frequency to the other is above the differential threshold, as defined in our discussion of Weber's law.

Pitch is also to some extent influenced by the physical correlates of loudness, which we will consider shortly. It has been demonstrated, for example, that a low pitch is made lower still if its loudness is increased beyond a certain point, and that a high pitch is raised still higher if its loudness is increased sufficiently.

The range of hearing

Our ears are not attuned to the whole range of frequencies. Auditory experiences in man are associated only with vibrations having from 20 to 20,000 cycles per second. A tuning fork vibrating at the rate of 15 cycles per second arouses no sound. A few people hear a very low tone before the frequency is increased to 20 cycles, but most do not hear anything until a frequency of 20 cycles or more is reached. All frequencies from this lower limit up to about 20,000 are heard by the normal ear. One method of testing this upper limit is to tap steel bars of successively higher frequencies. After the frequency gets to 16,000 cycles, a few fail to hear anything. As the 20,000 limit is approximated, more and more fail to hear the vibrating bar. At around 20,000 cycles practically everybody fails to hear any sound emanating from the bar.

Sometimes a whistle, the frequency of which can gradually be raised to 20,000 cycles or more, is used to determine the upper limit. This is known as the *Galton whistle,* because it was devised by Sir



221

The Limits of Human Hearing

Observe that the range of frequencies covered by the piano is from 28 to 4096 cycles. (After an illustration in the Encyclopaedia Britannica film, "Fundamentals of Acoustics.")

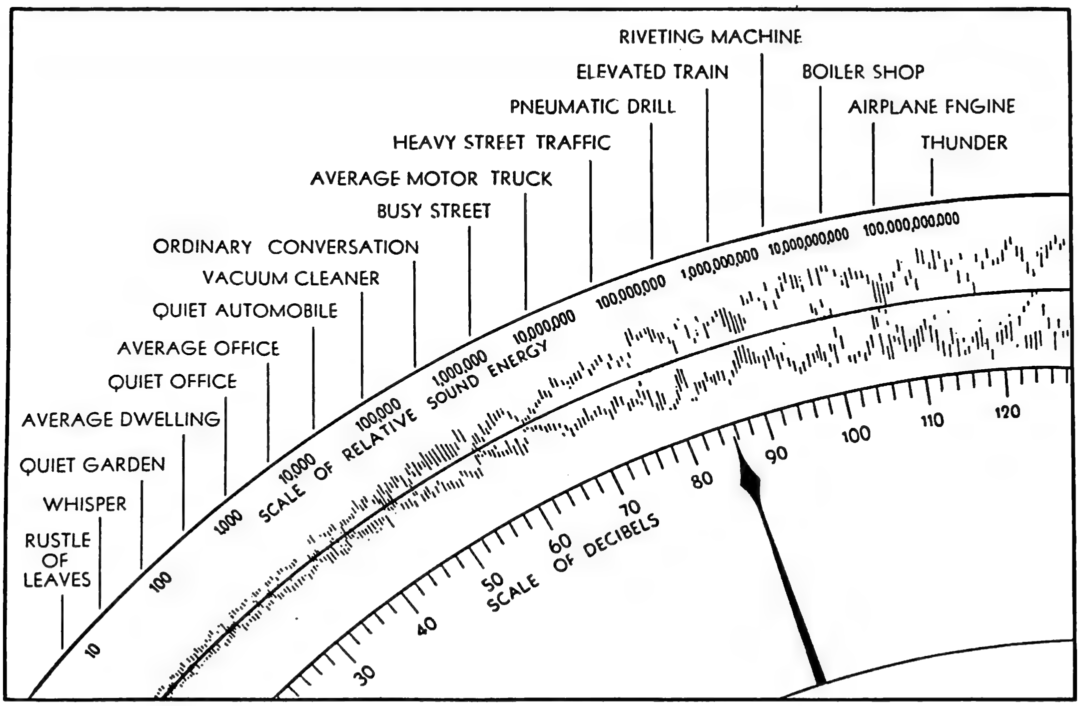
Francis Galton, who used it to test the upper limit of animals in the zoo by noticing whether or not they made any response as the rubber bulb of the whistle was squeezed. Similar whistles are used to call dogs. The dog responds to a frequency much higher than our limit; hence it responds to a whistle which the neighbors cannot hear.

The range of hearing in relation to frequency is illustrated in Figure 221. This figure also shows the range of frequencies utilized in the musical scale, as well as the differential sensitivity of the ear to certain frequencies within the auditory limits. The latter phenomenon will be considered presently.

Loudness and the amplitude of sound waves

Sound waves differ in amplitude as well as in frequency. Amplitude is represented on the oscillograph record by the maximum displacement of the writing point in either direction from its intermediate position, where, with the source of vibration inactive, it traces a straight line. Tuning-fork vibrations have their greatest amplitude at the beginning. Amplitude then decreases gradually and reaches zero as the prongs of the fork come to rest. Loudness decreases accordingly.

Amplitude of vibration determines the intensity of stimulation, the amount of pres-



222

Loudness of Some Familiar Sounds

This is a chart of sound levels indicated in decibels and in units of relative sound energy. Observe that one bel (10 decibels) is the logarithm (to the base 10) of the relative sound energy. A vacuum cleaner has a sound energy which is 100,000 times as great as a just-audible energy. This is 10 raised to the 5th power, hence the vacuum cleaner's loudness is 5 bels, or 50 decibels. (After a drawing in Electronics.)

sure or energy involved. Psychological intensity, or loudness, increases as stimulus intensity increases, and decreases as stimulus intensity decreases, provided the changes in stimulus intensity are sufficiently large to satisfy Weber's law. However, loudness also varies with frequency. In order to make them just barely audible, low and high frequencies require much more intensity than those between 1000 and 5000 cycles per second. This relation between frequency and loudness (audibility) was illustrated in Figure 221.

Loudness is usually referred to as so many *decibels* (*db*) above a certain standard, usually threshold intensity at a frequency of 1000 cycles per second. One *bel* is ten times the threshold intensity (in energy units); two bels, one hundred times the threshold intensity; three bels, one thousand times the threshold intensity; and so on. A bel is thus the logarithm to the base 10 of the ratio of the higher to the threshold intensity. A decibel is one tenth of a bel.

The rustle of leaves in a strong breeze has a loudness of about one bel, or ten db. Its energy is ten times that required to make a 1000-cycle tone just barely audible. On the other hand, busy street traffic in New York City has an energy level 10^8, or 100,000,000 times that required to make a 1000-cycle tone just barely audible. It is thus eight bels, or eighty db, louder than threshold loudness. Figure 222 gives the approximate loudness of some familiar sounds.

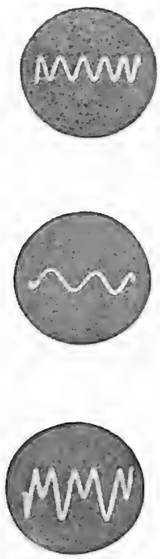
Timbre and the complexity of sound waves

Analysis of sound waves, and especially of those having great complexity, calls for an instrument much more delicate than the oscillograph already considered. A widely used instrument for such analysis is the *cathode-ray oscilloscope*, the basic features of which are illustrated in Figure 223. How this device operates is discussed in the legend.

As we have already observed, a tuning fork produces a pattern of condensations and

223 **A Cathode-Ray Oscilloscope**

The sound oo is being uttered. The cathode of the tube emits electrons which speed toward the anode, where a small hole allows some to be sprayed on the fluorescent screen. A greenish spot of light appears where they strike. Changes in potential cause the electrons to be deflected in a right-left direction. The spot thus sweeps rapidly from one side of the screen to the other. It moves back and forth so rapidly, in fact, that we see not a spot but a line. This line is deflected vertically by potential changes in the plates (vertical) connected with the microphone. A condensation striking the microphone deflects the stream of electrons upward and a rarefaction deflects them downward. Thus the line takes on a wavy appearance much like that of the oscillograph records already described. (Reproduced by permission from Davis, R. C., "Methods of Measuring and Recording Action," in Methods of Psychology *by T. G. Andrews. New York: John Wiley & Sons, 1948, p. 410.)*



224

Single and Combined Waves Produced by Two Tuning Forks of Different Frequency

These curves were photographed on the screen of a cathode-ray oscilloscope like that illustrated in Fig. 223.

rarefactions which records as a simple curve. Two forks of different frequency, but activated at the same time, produce a complex wave which, in appearance, masks their separate waves. This is illustrated in Figure 224, where the separate waves and then the combined waves are shown.

A sound wave of still greater complexity is produced when a taut wire is activated. When the wire vibrates as a whole, this arouses a predominant pitch known as the *fundamental tone.* However, the wire at the same time also vibrates in halves, thirds, quarters, fifths, and so on. These vibrations within the vibrating wire as a whole are known as *partials.* Each partial has its own pitch, known as an *harmonic* or an *overtone.*

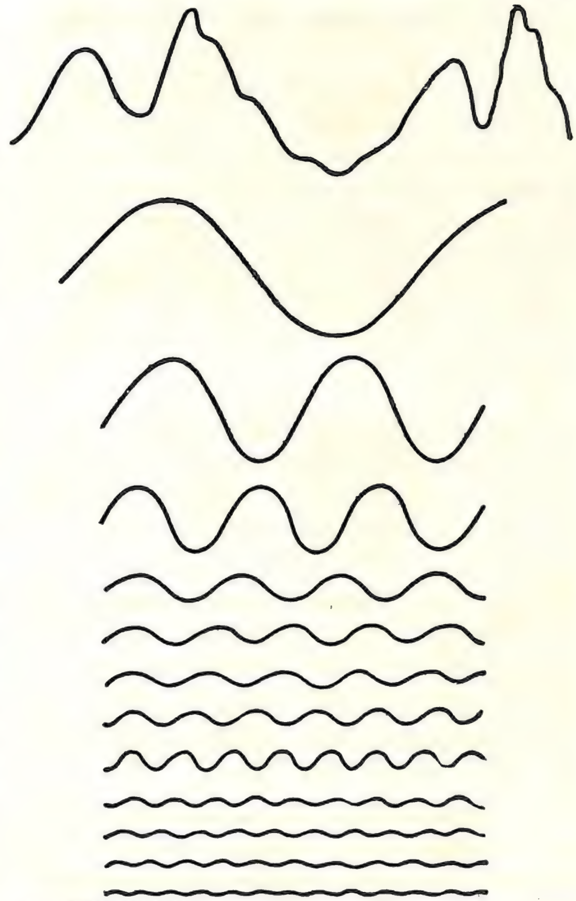
Overtones. When the wire is plucked, a loud complex sound is heard. However, if the vibrating wire is lightly touched (damped) in the middle with the tip of a camel's-hair brush, a simple tone of much higher pitch than the fundamental is heard. If the fundamental frequency of the wire is 256 cycles per second, the partial vibrations produced as above will have a frequency of 512 cycles per second, which is twice that of the fundamental. The tone heard is called the *first overtone.* If we now touch the vibrating wire at one third of the distance from either end, a still higher tone will be heard. This has a frequency three times higher than the fundamental, or 768 cycles per second. It is known as the *second overtone.* If we touch the wire at one fourth of the distance from either end, a frequency of 1024 cycles per second predominates, and we hear the *third overtone.* We may continue in this manner, touching the wire at one fifth, one sixth, one seventh of its length, and so on. At each step, a tone of higher pitch than the preceding one is heard. Since amplitude is reduced as the vibration involves shorter lengths of wire, loudness decreases as the successively higher overtones are isolated. After the ear has been trained to identify the lower overtones, it is possible to attend to them one at a time while the whole string is vibrating. That is to say, one may listen for and discern the first overtone, then listen for and discern the second overtone, and so on, up to perhaps the seventh or eighth.

All complex musical instruments give off many partial vibrations in addition to the fundamental. The pattern of condensations and rarefactions sent to our ear is extremely complex, and the pattern recorded on an oscilloscope is so complex that the eye is unable to discern its components. However, the component waves may be identified by mathematical or electrical analysis. Electrical analysis is obtained with the harmonic analyzer. Thus, the complex wave produced by an organ pipe is analyzable into the separate waves indicated in Figure 225. These are all simple sine waves like those produced by the tuning fork. Each has its own frequency, which is a multiple of the fundamental frequency.

Resonance. Different instruments not only produce different partial vibrations, but they also have different resonating qualities. In other words, they enhance certain overtones and deaden others. One instrument makes high overtones predominate, another the low overtones, another the intermediate overtones, and so on. The principle of resonance is easily demonstrated. Activate a tuning fork near a piano. Suppose, for example, that the tone is middle C (256 cycles). Wires in the piano will take up the vibration (resonate), and the maximum vibration will be that corresponding to middle C. If the tuning fork is damped, the piano will be heard emitting middle C. You may have noticed that tuning forks used in the physics or psychology laboratory are mounted on boxes of different sizes, and that, when removed from their box (resonator), they emit a relatively weak tone. The box, with the column of air contained, is so arranged that it takes up the vibration of the fork and enhances it. Even a wineglass vibrates when an appropriate note is struck near-by. It is claimed that a person with a powerful voice singing that particular note can shatter the glass at a distance, for its vibrations become so great in amplitude that it breaks.

Thus, the piano, violin, saxophone, and other instruments are constructed to provide resonance for certain of the partials and not for others, or to provide different resonance at different times, depending upon the needs of the moment.

That the difference in overtones gives different musical instruments their characteristic sound quality or timbre may be demonstrated by use of sound filters. These reduce the complexity of sound waves reaching the ear by eliminating partials, and consequently overtones. As more overtones are eliminated, differences in timbre become less noticeable. If the tone middle C is produced on, respectively, a piano, a 'cello, and a French horn, each instrument has its easily recognizable timbre. However, when all of the overtones but the fundamental (256 cycles) are prevented from reaching the ear, the tones from the different instruments are almost alike, and, unless one knows which instrument is being played, he fails to recognize its tone. As more and more overtones are admitted to the ear, the characteristic sound qualities of the respective instruments reappear. These facts are very neatly illustrated in a phonograph record produced by the Bell Telephone Laboratories.



225 Analysis of an Organ Pipe Wave into Its Components

Every musical instrument has a somewhat different wave-complex, and this is why each has its characteristic quality. (From Miller, D. C., The Science of Musical Sounds. *New York: Macmillan, 1926, p. 125.)*

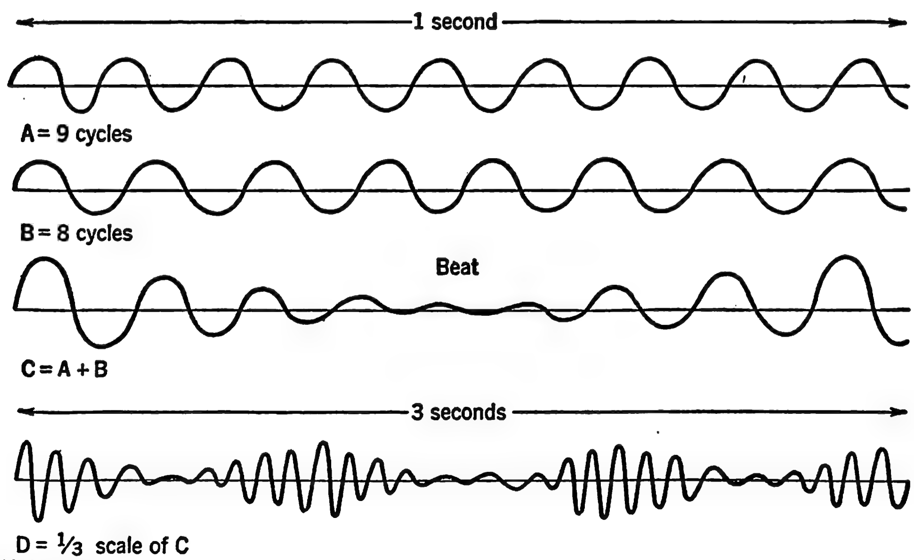
SOME OTHER AUDITORY PHENOMENA

The phenomena so far considered in this chapter are those related to determination of pitch, loudness, and timbre. We now turn to certain other phenomena aroused when the ear is simultaneously stimulated by different frequencies. These phenomena are beats, combination tones, and masking.

Beats

If two tuning forks differing by one cycle per second are activated simultaneously, there is a fluctuation in loudness which occurs once per second. This is known as a *beat.* The number of beats per second increases as the difference in frequency of the two sounding bodies increases. Thus, forks of 256 and 257 cycles produce one beat per second; forks of 256 and 258 cycles, two beats per second; forks of 256 and 259 cycles, three beats per second; and so on. It is possible to hear these periodic fluctuations in loudness long after they have become too frequent to count.

The physical basis of beats is a difference in phase of the two sound waves. When two tuning forks of like frequency are activated simultaneously, they keep in phase. The crest, trough, and other positions of the wave are alike for each. They reinforce each other and make a combined tone louder than that produced by either fork alone. When two forks differing by one cycle per second are activated, however, they are completely in phase once per second (increasing the loudness of the sound), and completely out of phase once per second (approximating silence). In other words, the crests coincide once per second. Periodic facilitation and interference are illustrated graphically in Figure 226. The beat that we hear corresponds with the fluctuating phase relation-



226

Wave Interference Producing Beats

Observe that the amplitude of wave C *is reduced when the trough (lowest position) of wave* A *and the crest (highest position) of wave* B *coincide. There is similar coincidence per second for each cycle of difference between the two sounding bodies. (After E. G. Wever in Boring,* et al., Introduction to Psychology. *New York: Wiley, 1939, p. 583.)*

ship. As the difference in frequency of the two vibrating bodies increases, there is a corresponding increase in the frequency of fluctuations.

Combination tones

When two sound generators separated by a frequency of thirty cycles or more are activated simultaneously, we hear (1) a tone corresponding to the difference between the generating frequencies and (2) another tone with a frequency which is the sum of the two generating frequencies. The first of these tones is known as the *difference tone* and the second as the *summation tone.*

Difference tones. When steel bars (or other devices), with the respective frequencies of, say, 2700 and 2800 cycles per second, are activated simultaneously, one hears a low hum with a frequency of 100 cycles per second. This is heard in addition to the two primary tones. If bars which have the frequencies of 2700 and 2900 cycles per second are now struck, the difference tone is much higher — almost bell-like in quality. Its frequency is 200 cycles per second. As the frequency difference between the two bars is gradually increased by steps of 100 cycles at a time, the intermediate tone rises correspondingly in pitch.

Summation tones. When bars which have the frequencies of 2700 and 2800 cycles are struck simultaneously, one may hear a tone corresponding to a frequency of 5500 cycles. This, the summation tone, is difficult to hear. In order to hear it, one must listen for a tone of higher pitch than either of the generating frequencies, ignoring these and the difference tone. If one does hear a higher tone than the highest frequency generated, he is hearing the summation tone.

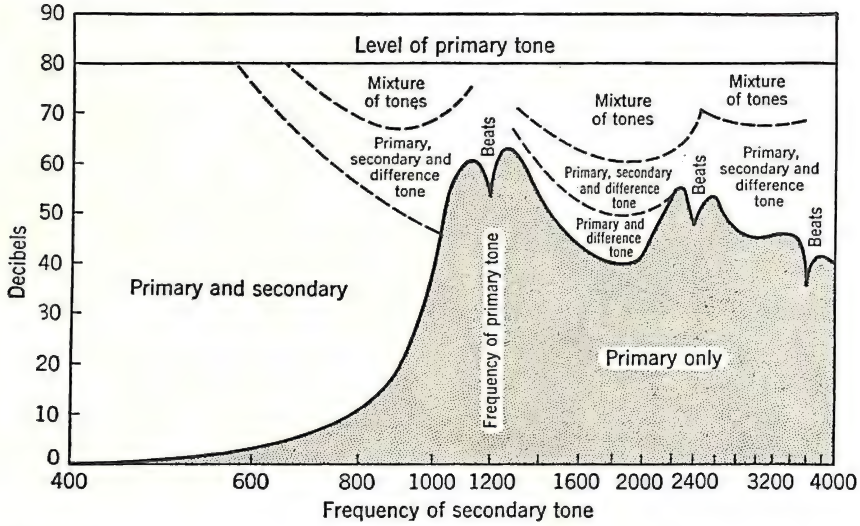
Difference and summation tones from harmonics. The harmonics, or partials, also produce difference tones and summation tones, although these are not easily differentiated from the total sound effect. Suppose, for example, that we simultaneously activate two wires having frequencies, respectively, of 256 and 356 cycles per second. There will be a difference tone of 100 cycles, and a summation tone of 612 cycles. However, the first wire also has a frequency of 512 cycles (first overtone), and the second also a frequency of 712 cycles (first overtone). The difference between these vibrations is 200. It will produce a difference tone of corresponding pitch. The sum of the two frequencies is 1224, and it will produce a summation tone of corresponding pitch. The differences and sums of each of the higher partials likewise produce difference and summation tones.

Masking

It is well known that one tone or noise may make another inaudible — that is to say, mask the other. The masking effect of a particular sound may be determined by observing how many decibels the masked tone must be raised above the normal level of intensity in order to make it audible in the presence of the masking tone. Some of the most important relationships between masked and masking tones are illustrated in Figure 227. The interpretation is given in the legend.

Low tones have a greater masking effect than high tones. The masking effect is increased as the two tones (the masking and the masked) come close together in frequency.

Psychological research on auditory phenomena like those discussed in this section has many practical applications. Psychoacoustic laboratories are focusing much of their effort upon such problems as how to adapt hearing aids to particular auditory limitations, how to improve the intelligibility of speech in intercommunication systems, how to utilize visual wave patterns in teaching the deaf to "read" speech, the use of the beam and of flybar in aviation, and the



227

Tonal Masking

This figure shows the masking effect of a 1200-cycle (primary) tone, with an intensity level of 80 db, upon frequencies (secondary) ranging from 400 to 4000 cycles. These frequencies are represented along the base (abscissa) of the graph. How much each frequency must be raised in intensity above its normal threshold (when the masking tone is not present), in order to overcome the masking effect, is shown at the side (ordinate) of the graph. The shaded portion of the figure indicates the intensity levels at which the respective frequencies are inaudible (masked). Above this shaded portion are the intensity levels at which no masking of the respective frequencies by the 1200-cycle tone occurs. Above these intensity levels, in other words, both the primary and secondary tones are heard. One will observe, for example, that a tone of 600 cycles per second need be raised above its normal threshold by only 3 db in order to overcome masking. On the other hand, a tone of 1600 cycles must be raised to 45 db above its normal threshold in order to become audible. Note that beats and combination tones occur when frequencies are close to the masking frequencies. Harmonics of the primary tone (2400 and 3600 cycles) also produce beats and combination tones with secondary tones near them in frequency. At the places where beats occur, the masking effect is slightly overcome, as represented by dips in the curve. In general, the results reproduced here show that frequencies much lower than the masking frequency are not masked as much as higher frequencies, especially those fairly close to the masking frequency. (After Wegel, R. L., and Lane, C. E., "The Auditory Masking of One Pure Tone by Another and Its Probable Relation to the Dynamics of the Inner Ear." *Phys. Rev.*, 1924, vol. 23, pp. 266–285.)

reduction of noise in our large cities and in industry.*

* Many of these developments are discussed in *Applied Experimental Psychology* by Chapanis, Garner, and Morgan. See the suggestions for further reading at the end of the chapter. Flybar refers to a particular system of auditory signals which indicate to the pilot when he is performing incorrectly, the direction of error, and the amount of error with reference to keeping the plane straight, right side up, and at the right altitude.

SOME STRUCTURAL AND FUNCTIONAL CORRELATES OF HEARING

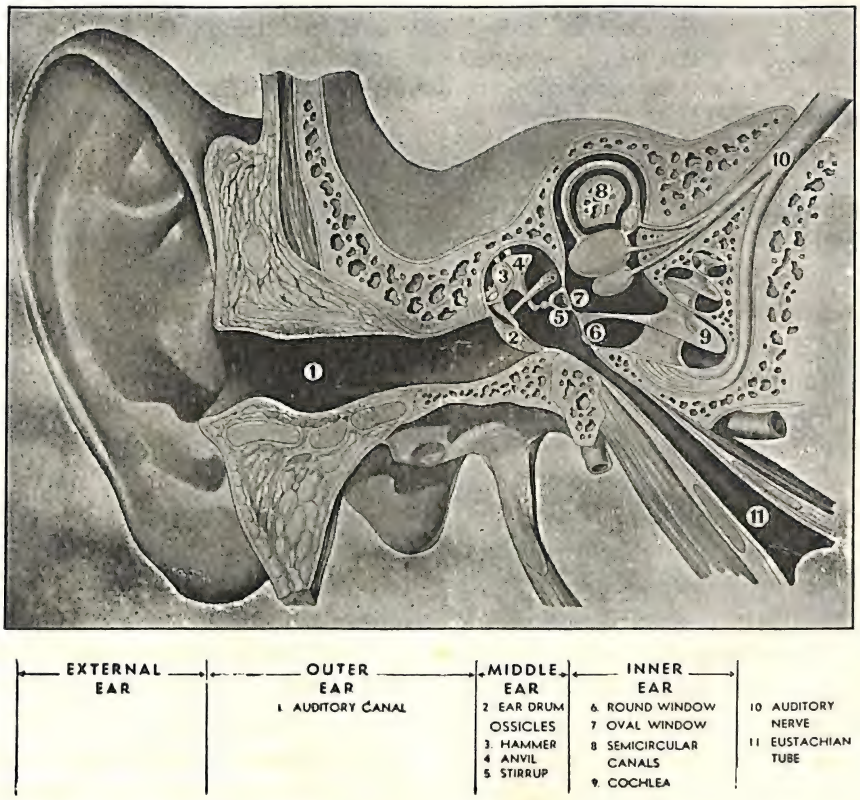
Sound waves must give rise to nerve impulses, and these must be transmitted to the brain before we hear. For this reason, psychologists are interested in the auditory mechanism and its functions. We are especially interested in discovering the physio-

logical basis of pitch, loudness, timbre, beats, combination tones, and masking. Theories of hearing, three of which will be considered after the auditory mechanisms have been described, are attempts to correlate the phenomena of auditory experience with what is known about auditory structures and functions.

Auditory mechanisms

The gross anatomy of the ear is illustrated in Figure 228, which also shows the semicircular canals and the vestibular branch of the auditory nerve, neither of which has anything to do with hearing. We will consider the latter structures when we discuss the static sense.

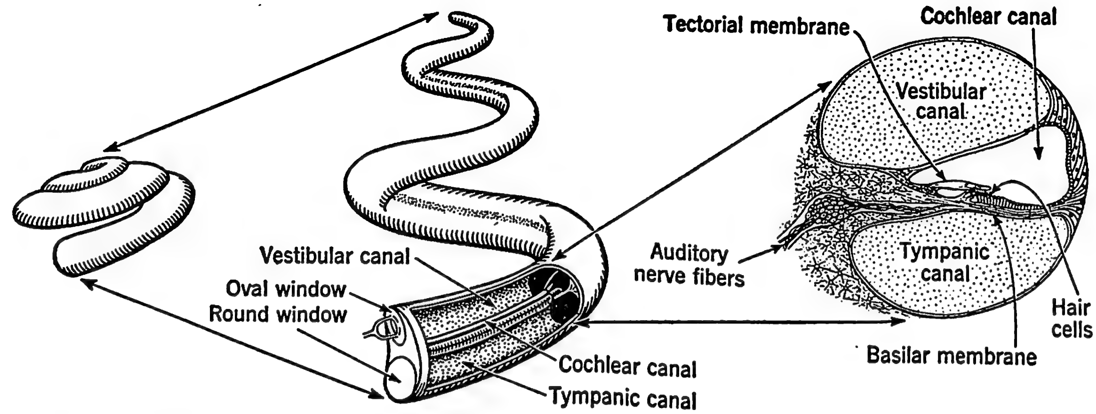
Sound waves travel through the external canal until they strike the *tympanic membrane* (eardrum). Vibration of this membrane activates the attached *hammer* and, through it, the *anvil* and *stirrup*. Attached to the hammer is the *tensor tympani,* a muscle with which we are already familiar (p. 388). This muscle adjusts hammer and tympanic membrane for different intensities in such a manner as to prevent injury to the membrane. The stirrup, which also has a muscular attachment (not shown) presses



228

A Diagrammatic Cross-Section of the Human Ear

Observe that the auditory nerve has two branches. One of these, the vestibular, connects with the semicircular canals and serves the static (equilibratory) sense. The other branch, the cochlear, is auditory in function. (Courtesy of the Otarian Company.)



229

The Cochlea

A, The cochlea, coiled as it is in position in the inner ear. B, The cochlea partly extended and sectioned to show the internal structure. C, The cochlea in cross-section, showing the organ of Corti, and hair cells. (Arranged from various sources.)

against the *oval window.* Its movements press the membranous window in and out. Movements of the oval window cause waves to travel up the *vestibular canal* and back down the *tympanic canal* of the *cochlea.* Both canals are filled with liquid. A push of the stirrup is compensated for by an outward bulge of the *round window,* which appears at the lower extremity of the tympanic canal. Withdrawal of the stirrup causes an inward bulge of the round window.

What we have here is actually a single long liquid-filled canal which ascends, then descends. This is illustrated in Figure 229, B, where the cochlea is represented as uncoiled. The place at which the canal reverses its direction is the *helicotrema,* situated at the apex of the cochlea. The entire structure is coiled in the form of a spiral with two and one half turns.

Separating the two large canals of the cochlea is a ledge of bone and other tissue. It contains two thin membranes which enclose a small channel known as the *cochlear canal.* It is in this that the true auditory receptors are located.

A cross-section of the uncoiled cochlea is represented in Figure 229, C. Here we see the relation of the three canals to each other. The cochlea canal is separated from the vestibular by *Reissner's membrane,* and from the tympanic by the *basilar membrane.* On the basilar membrane is the *organ of Corti,* the hair cells of which project up into the liquid which fills the canal. These cells connect with dendrites of nerve fibers which run along the center of the cochlea and then out into the cochlear branch of the auditory nerve. The *tectorial membrane* is above the hairs, whose upper ends project into it.

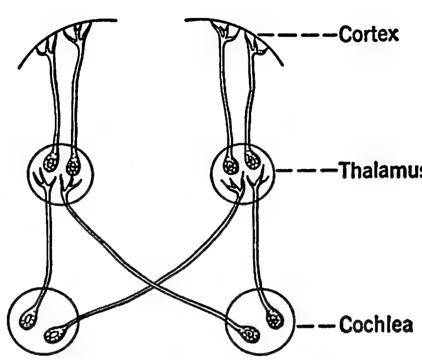
The basilar membrane is set in motion whenever a disturbance occurs in the ascending (vestibular) and descending (tympanic) canals. This motion has been characterized as a traveling wave or bulge. Certain parts of the membrane are apparently attuned to different frequencies, so that, when these frequencies activate the ear, the corresponding parts are bulged to a greater degree than others.

The basilar membrane itself is a harplike structure with fibers ranging in length from

short to long. Fibers are shortest at the base of the cochlea, where most of the bulk is merely connective tissue. They become progressively longer as the apex (which has very little connective tissue) is approached. The region containing short fibers bulges maximally when high frequencies are present, while the region containing long fibers bulges most in response to low frequencies.[1]

Activity of the basilar membrane moves the organ of Corti, the hair cells of which are induced to bend. This bending excites the dendrites of nerve fibers associated with the hairs. Hair cells are activated to the greatest degree, presumably, in the region of the basilar membrane in which maximal disturbance is taking place.

Nerve impulses aroused by the hair cells of Corti travel to the thalamus, where synaptic connections with fibers running to the temporal lobe of the cerebrum are made. The course followed by these impulses is illustrated schematically in Figure 230. Observe that each ear is connected with both sides of the cortex. Thus, loss of one temporal lobe does not produce complete deafness in either ear. Loss of both temporal lobes in man produces complete deafness. Some animals, however, continue to respond to noise after the entire cerebrum has been removed. In such instances it is apparent that the thalamic connections are alone necessary for response to noise.



230 **Schema to Show How Each Ear is Connected with the Cortex**

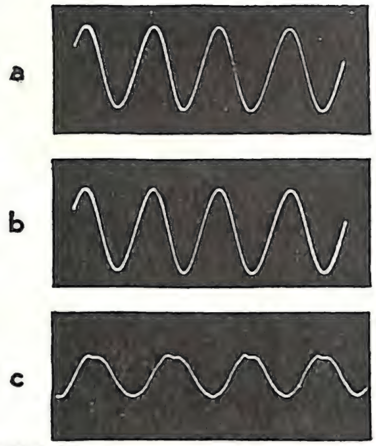
You can see from this diagram why injury to one temporal lobe renders neither ear completely deaf. (After Morgan, C. T., Physiological Psychology. *New York: McGraw-Hill, 1943, p. 236.)*

The Wever-Bray effect

Frequencies which stimulate the ear are, within certain limits, faithfully reproduced in the cochlea and auditory nerve. This is called the *Wever-Bray effect,* after the two psychologists who discovered it.[2] The phenomenon was first demonstrated with cats. Electrodes placed on an anaesthetized cat's auditory nerve led into a soundproof room, where they were connected with a radio amplifying system. This was in turn connected to a telephone earpiece. Various frequencies played into the cat's ear were faithfully reproduced. The corresponding pitch was heard by anyone listening at the earpiece. Even the human voice was reproduced. One experimenter spoke into the cat's ear and the other, seated in the soundproof room, heard clearly what he said.

Subsequent research[3] has shown that the Wever-Bray effect is really two effects. One of these, the *cochlear response,* involves electrical phenomena originating in the cells of the cochlea as these are stimulated by external vibration. The other, known as the *nerve potential,* is purely a neural response, although aroused, presumably, by the phenomena which produce the cochlear response. Within certain limits, both the cochlear and nerve potentials have a frequency correlated with that of the stimulus. Some typical correlations appear in Figure 231.

The cochlear response. Sound waves sent into the ear produce electrical currents in the cochlea, perhaps through the activity of hair cells. This electrical response, sometimes referred to as the cochlear microphonic, is recorded from electrodes placed directly on the cochlea. By moving the



231 **Some Correlations between Stimulus Frequency and Cochlear and Nerve Potentials**

Records a *and* b *represent a frequency of 1000 cycles:* a *shows the record from a microphone;* b, *that from the cochlea of a guinea pig. Record* c *shows cochlear and nerve potentials combined. The tone had a frequency of 150 cycles. Nerve potentials are shown by the variation (spike) at the peak of each wave. (Arranged from Wever, E. G.,* Theory of Hearing. *New York: Wiley, 1949, pp. 137 and 141.)*

electrodes from place to place along the basilar membrane, it is possible to discover which region responds maximally to a particular frequency. It has been shown, by such methods, that the short fibers (base of cochlea) respond maximally to high, and the long fibers (apex of cochlea) respond maximally to low frequencies. The frequencies which generate cochlear responses range from 20 to 20,000 cycles per second. At high intensities, a pure tone produces a complex cochlear response, showing the presence of harmonics in the cochlea itself. These are distinguished from harmonics in the sound source by referring to them as *aural harmonics.*

Auditory nerve potentials. With suitably shielded electrodes attached to the auditory nerve, it is possible to pick up the neural responses alone. Under these conditions, external frequencies up to around five thousand cycles per second elicit corresponding frequencies in the auditory nerve. See the spikes in Figure 231, C.

It is especially interesting to observe that, while a single nerve fiber carries less than one thousand impulses per second (p. 52), the auditory nerve itself carries up to around five thousand per second. This fact, as we shall observe shortly, is important for theories of hearing. It is also significant that the auditory nerve does not appear to carry frequencies above five thousand per second. This suggests that some factor other than frequency of nerve impulses must account for our ability to hear pitches corresponding to higher frequencies of vibration.

THEORIES OF HEARING

Theories of hearing attempt to fit together the facts of auditory experience on the one hand, and what is known about the structures and functions of the auditory mechanism on the other. They are especially concerned with the physiological basis of pitch and loudness. You should know something about the most important of these theories because, like the theory of color vision already discussed, they bring to a focus much of what is now known about an important avenue of contact between the objectively measurable external world and man himself.

Place theory

This was presented in its original form by Helmholtz, who thought that the fibers of the basilar membrane resonate to external frequencies somewhat like wires in a piano. In its present form the place theory supposes that each region of the basilar membrane is especially attuned to a certain frequency of vibration. Thus, a particular narrow region

of the basilar membrane is supposed to react maximally to a certain frequency, although other parts are also to some extent activated. Our experience of pitch would depend upon the part of the basilar membrane which gives the maximal response to a vibration frequency. It is generally supposed, however, that impulses aroused in different regions of the basilar membrane go to different regions of the temporal lobe. Thus, the cortical region affected would be the most immediate correlate of a particular pitch experience.

We have seen that, although its fibers do not vibrate, the basilar membrane does act differentially to different frequencies. This was shown in our discussion of the cochlear response. There is also evidence, although somewhat conflicting, that exposure of an animal's ear to loud sounds of high pitch destroys the basal region of the cochlea, where the short fibers — those assumed by the place theory to function for high pitch — are located. Low tones of great intensity produce widespread rather than localized damage to the basilar membrane.[4]

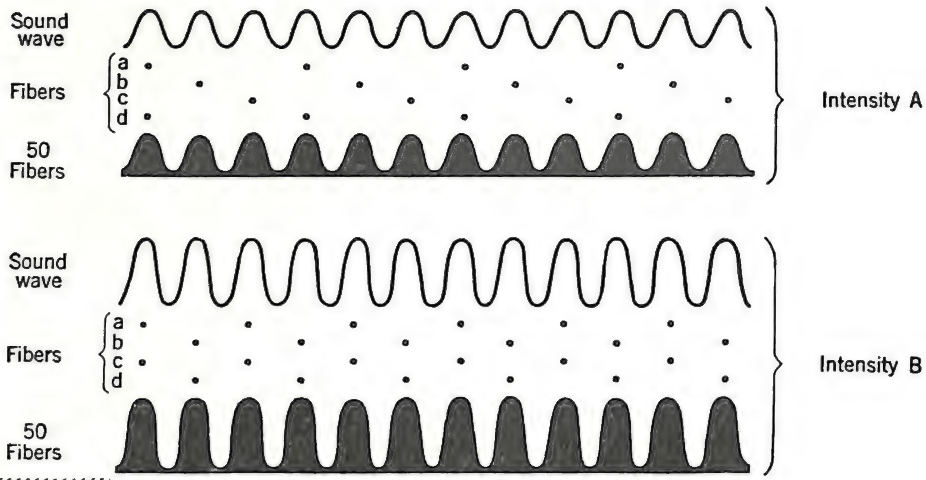
According to the place theory, loudness depends on how much of the basilar membrane is activated. Two tones of the same frequency and intensity would activate the same range of fibers. Moreover, the same particular fibers would be activated maximally. If the two tones of like frequency differed in intensity, however, the range of fibers activated would be greater in the case of the greater intensity, even though the fibers maximally activated would be the same. In other words, according to the place theory, pitch depends upon the place maximally activated, and loudness upon the spread of disturbance in either direction from the place most involved.

Frequency theory

There are several frequency theories of hearing. One of these (Rutherford's) supposes that the ear works much like a telephone receiver. It assumes that a frequency of, say, ten thousand cycles per second, causes the auditory nerve to carry ten thousand impulses per second to the brain. Pitch is thus supposed to depend upon the frequency of nerve impulses reaching the brain. Loudness is assumed to depend on the number of auditory fibers activated. Overtones, beats, and the other phenomena of hearing are attributed to some sort of analysis by the brain of the impulses which come to it. However, unless the volley theory is invoked, frequency cannot account for pitch experiences above one thousand cycles per second.

The volley theory

This is a modified frequency theory. It was presented by Wever and Bray to account for the Wever-Bray effect. One will recall, from our discussion of the Wever-Bray effect, that frequencies of vibration up to about five thousand cycles per second are somehow transmitted by the auditory nerve, even though no single fiber responds more frequently than one thousand times per second. This suggested that nerve fibers work in squads, different squads firing, as it were, at each condensation of the external stimulus, as illustrated in Figure 232. A group of fibers would discharge at one condensation, but not at the next. Some fibers in the group, because of their greater excitability, would discharge more often than others. Some might be in the refractory phase at the first condensation, but be ready to respond to the next. (For the sake of simplicity this disparity in frequency of discharge by different fibers is not shown in Figure 232.) In other words, despite wide differences in the excitability of different fibers in the auditory nerve, there would be a spurt of impulses involving some fibers every time a condensation occurred. There would be some discharges between the peaks of these spurts, but there would



232

The Volley Principle

In the upper figure note that, for each condensation of the sound wave, some fibers, say 50 respond. Fiber a *responds at every third condensation starting with the first; fiber* b *responds at every third condensation starting with the second, and so on. Although no one fiber responds at each condensation, all respond in synchronism with the external frequency. The mound at the bottom represents the sum of all impulses aroused by each condensation. Note that there is a mound for every condensation, because each condensation is assumed to produce its own spurt of neural activity. The frequency of these spurts or volleys is said to be the physiological basis of pitch. The lower figure shows that the sound wave, while of the same frequency as above, has greater amplitude. Fibers* a, b, *etc., react to every second instead of only to every third condensation. In effect, the frequency of volleys is unchanged, but more impulses are added to each volley. The mounds at the bottom are spaced like those above, but their height is greater. (From Wever, E. G., in Boring, Langfeld and Weld's* Introduction to Psychology. *New York: Wiley, 1939, p. 596.)*

be a peak for every condensation and a low point for every rarefaction of the stimulus. Thus, for a tone of three thousand cycles per second, there would be a spurt of activity in the auditory nerve every three thousandths of a second, with different groups of fibers responding each time, and some fibers, because of greater excitability, contributing to more of the spurts than others. Pitch, according to this theory, is thus dependent upon the frequency of *volleys,* not the frequency carried by the individual fibers.

Loudness is accounted for by supposing that, with an increase in the intensity of stimulation, more impulses occur in each spurt. We have already learned (p. 53) that an increase in the intensity of stimulation causes more fibers to respond and also leads to a more frequent response in each fiber. Thus, a condensation of increased amplitude might activate one hundred instead of fifty fibers; and fibers which had been responding only five hundred times per second might now respond seven hundred times per second. The total effect would be to produce more impulses per volley, without changing the frequency, or temporal distance, of the separate volleys.

At the present time it seems apparent that both the volley and place principles are involved in hearing, with the volley factor playing a major role in mediating frequen-

cies up to around five thousand cycles and the place factor a major role in mediating higher frequencies. Although there is much to be learned about how these principles operate, especially in producing complexities of hearing like overtones, beats, combination tones, and masking, both appear necessary. As Wever says,

> There seems little room for argument now as to the validity of the two principles. Each rests upon substantial evidence. Yet . . . neither by itself is sufficient. One alone is unable to account for all the phenomena of auditory experience. It is only in their harmonious combination that we come to a full realization of our explanatory purpose; together, assisting and supplementing one another, they produce a complete theory.[5]

AUDITORY SPACE PERCEPTION

Our ears provide us with certain cues concerning both the *distance* and *direction* of objects, but judgments based upon these cues are in most instances quite crude, especially compared with judgments based on visual cues.

Distance

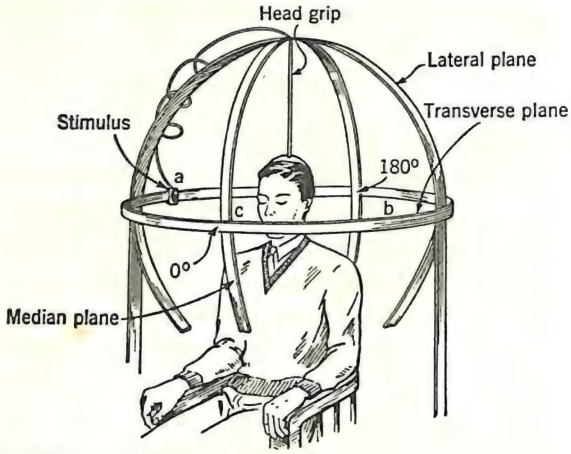
If a sound is familiar, we can usually judge its distance in terms of loudness, since we associate increasing distance with decreasing loudness. Complexity is another possible distance cue. The sound of an airplane motor is far less complex at a distance than when near-by. When it is close, we hear a great variety of sounds. At a distance, however, only the low hum is audible. Likewise, the relatively faint higher overtones of musical instruments become inaudible with distance. Near-by sounds also have greater volume than more distant ones. The boom of a cannon a few yards away seems to fill all space. From a distance of several miles, however, the same boom appears to take up relatively little space. Moreover, it is heard as but one of several sounds. It does not drown out everything else.

Direction

Our ability to locate sound sources is partially dependent upon previous knowledge. We know, for example, that those traffic sounds are coming from the road over there, that the airplane is overhead, and that the cheering comes from the stadium. Vision also provides us with cues which aid in auditory localization. We hear a woodpecker, for instance. Looking up in the trees and seeing the bird pecking, we locate the source of the sound. It happens, of course, that vision sometimes deceives us. We "hear" sounds issuing from the mouth of the ventriloquist's dummy because we see its mouth moving at the same time as words are spoken. Likewise, we seem to see and hear an actor speak on the screen, even though the loudspeaker may be several feet above, below, or to the right or left of his mouth.

Under such circumstances as the above, only one ear is necessary for localization. All we need do is hear and recognize what we hear. When previous knowledge and vision are eliminated, however, two ears are necessary for localization. This is because we are not able to localize sounds in terms of auditory cues alone unless they stimulate each ear differently.

In a typical experiment on auditory localization the subject sits with closed eyes, his head in the center of what is, in effect, a large sphere. This is illustrated in Figure 233. A click may be presented at any position on the surface of the sphere. As soon as he hears the click, the subject must name or point to the place from which the click came. His error of localization is measured in degrees. We find that he is able to localize the click fairly well so long as it is at a different distance from each ear. When it appears at *a,* the click is much closer to the right ear than to the left. The subject usually points



233

Schema Illustrating a Situation Involved in Auditory Localization Experiments

For explanation, see the text.

directly to the right. Suppose that the click is presented at *b* — that is, to the front on the left side. It is closer to the left ear than to the right. Again the subject has good success in pointing to the source of the click. Suppose, however, that we present the click directly in front at a position equidistant from the ears — that is, at *c*. Now the subject may point up, back, down, to the front, or to any position in the median plane, which cuts through the head directly between the ears. His accuracy of localization within this plane is no better than could occur by chance. This is because, at every position, the ears are stimulated identically.

What differences in stimulation at the ears are provided by a sound to the right or left of the median plane? There are three important possibilities. These are: (1) a difference in time of arrival of the sound wave at the ears; (2) a difference in the phase of the cycle activating both ears; and (3) a difference in the intensity of the stimulus at the ears. The sound wave, of course, reaches the nearer ear first; it may be in a different part of its cycle when it strikes the nearer ear than when it strikes the farther ear, and it may have a greater intensity at the nearer than at the farther ear.

Under conditions of everyday life, time, phase, and intensity differences are often simultaneously present, and we may use now one and now another, or all three combined, in localizing unfamiliar and unseen sounds. When the locus is familiar, or the sound source seen, these cues are not necessary, and they are probably not used. When a noise, such as a click, is involved, time is the most important clue as to direction. But when a tonal stimulus is involved, phase also becomes important, especially if the sound wave is of low frequency, hence relatively long. A long wave has a better chance of stimulating the two ears in a different part of its cycle than a short wave. One ear may be stimulated by the crest (condensation), and the other by the trough (rarefaction). In the case of high frequencies, or short waves, on the other hand, one ear may be stimulated by the crest of one wave and the other ear by the crest of the next wave. As far as phase is concerned, this is equivalent to stimulating both ears with the crest of the same wave. Experiments have shown that some individuals localize in terms of phase differences, but others do not.

Intensity is an important cue only at relatively high frequencies, above five thousand cycles per second.[6] This is because intensity is not greatly reduced by small differences in the distance of a sound source from the ears. Significant differences in intensity are associated, rather, with the shadow of the head. In other words, a sound wave coming from the right must pass around the head to get to the left ear. Long waves (those of low frequency) bend easily and show little loss of amplitude. On the other hand, short waves (those of high frequency) are so greatly reduced in amplitude that the sound may be thirty db louder at the nearer than at the farther ear.[7] When complex sound waves are involved, this bending around the head not only reduces their loudness, but it

also decreases their complexity. Timbre is thus different at the two ears and may provide a localizing cue.

When one wears an apparatus like that shown in Figure 234, all the auditory localizing cues are reversed. If the eyes are closed, sounds actually coming from the right are heard coming from the left, and vice versa. If the eyes are open, however, and the sound source is within view, the sounds are properly localized. In other words, visual cues take precedence over auditory ones.[8]

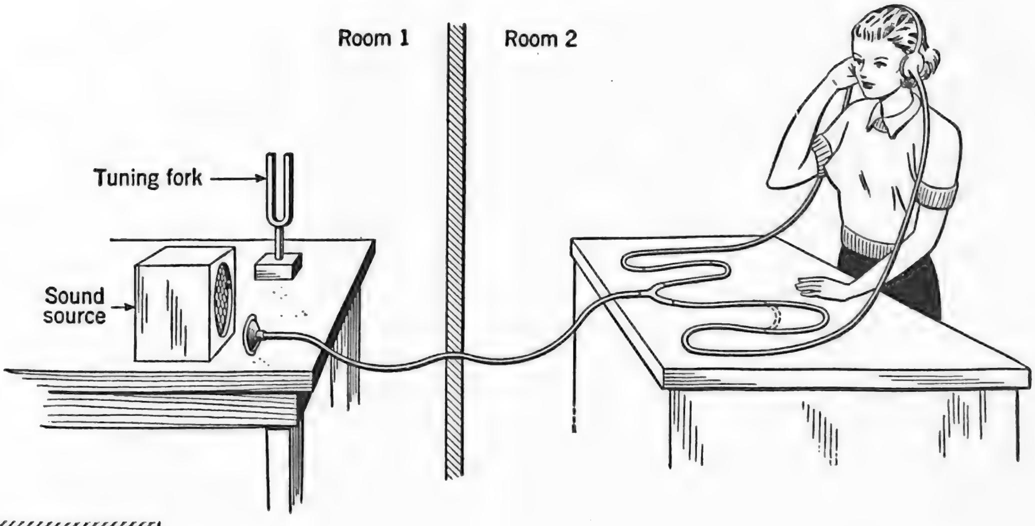
It is only under laboratory conditions that we are able to present one of these localizing cues while holding the others constant, and thus discover the relative importance of each.

The time cue. A subject sits with an earpiece over each ear, somewhat as illustrated in Figure 235, and a clicking sound is generated immediately in front of him. If both ears are stimulated simultaneously with a click, the sound is localized in front. But if the situation is arranged so that the click reaches one ear .001 second before it reaches

234

Young's Pseudophone

A tube conveys to the left ear sound waves which would normally stimulate the right ear, and to the right ear those which would normally stimulate the left ear.



235

Apparatus for Studying Time and Phase Cues in Auditory Localization

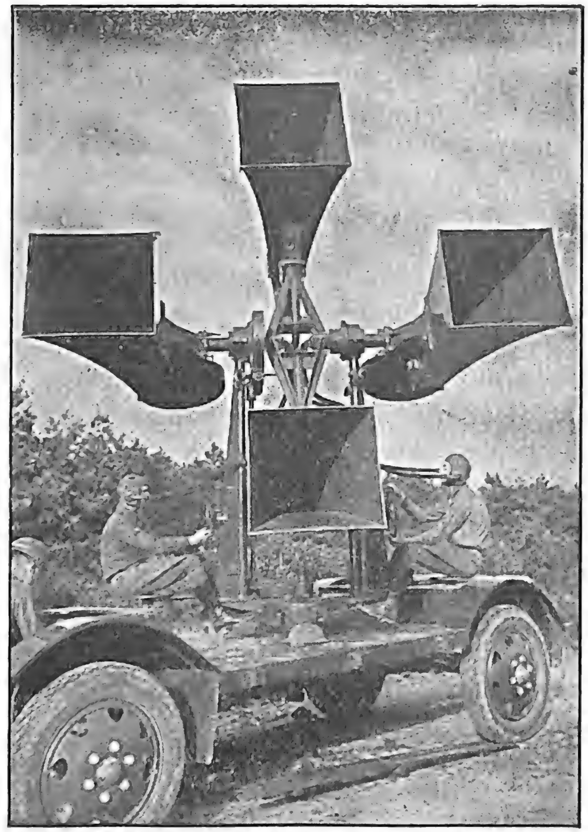
Lengthening one tube delays the arrival of the sound wave at the corresponding ear, thus seeming to shift the sound to the opposite (in this case the right) side. (Modified from Harrower.)

the other, the sound seems to shift to the side of the ear stimulated first. If the interval is too long, two clicks are heard.

The phase cue. When a tuning-fork sound replaces the click, there is a periodic wave. Now a lag in the stimulation of one ear changes the phase relation. The ear stimulated first may, for example, get the crest of the wave while the other is getting the trough, or some other part of the cycle. If both tubes are equally long, the phase relation is identical at the two ears, and the tone is heard coming from the front. But if one tube is slightly lengthened, the phantom sound is displaced from the front toward the ear with the shorter tube — the one with the leading phase. Making this tube now shorter than the other shifts the sound toward the opposite ear. The intensity change in this experiment is too small to serve as a cue, hence the emphasis on phase.

The intensity cue. The importance of intensity as a basis of auditory localization is studied by stimulating both ears simultaneously with a sound located in front of the subject. When both ears receive equally intense stimulation, the sound is localized to the front. But when one ear is more intensely stimulated than the other, the phantom sound moves toward that ear. Indeed, the angular displacement of the phantom sound can be moved to various positions between the two ears by altering the intensity differential.

Under conditions of everyday life we are, of course, free to move our head, thereby changing time, phase, and intensity relations. In localizing a sound, we sometimes turn around until we face its source, thus equalizing stimulation of the ears. Sound locators like that illustrated in Figure 236 are used by the armed forces to locate planes, guns, and other objects. The apparatus consists, essentially, of two large "ears" separated by a wider than normal distance so that intensity differences are enhanced. The artificial ears are connected by telephone to the operator's ears. In finding the direction of a sound, the operator turns the "ears" until the sounds in his ears are equal in loudness. The source is then assumed to be in the median plane. The apparatus can then be worked in the vertical position, thus locating the direction of the sound within the median plane. This is equivalent to turning the operator's ears sideways, one up and one down.[9]



236 **A Sound Locator**

This is one of several models used by the armed forces. (Courtesy of Life.*)*

Auditory perspective

In any complex situation, some sounds appear near and some distant; some appear

to the right, some to the left, and some straight ahead. Not only this, but certain sounds move in relation to other sounds or appear on a background of constant sounds. Radio engineers have had some success, although not commercially, in reproducing such *stereophonic effects* by radio. One method is to place two microphones on a dummy, one microphone in the position of the right ear and the other in the position of the left ear, maintaining the actual distance which separates the ears. The right-hand microphone is connected to the right earphone of a listener in another room. The left-hand microphone is likewise connected to the left earphone. Now someone walks toward or away from the dummy, around it, and so on, while talking. The listener with earphones has the illusion that someone is walking toward him, around him, and so forth.[10]

SUMMARY

Pitch is correlated with the frequency of sound waves, loudness with their amplitude, and timbre with their complexity. Noise differs from tone in that the sound waves correlated with noise are relatively lacking in periodicity. The range of frequencies to which human ears are attuned is from about twenty to twenty thousand cycles per second. Our ears are most sensitive to frequencies between one thousand and five thousand cycles per second. Within this range, relatively weak intensities are audible. Lower and higher frequencies become audible only when present at relatively high intensity.

Physical intensity and psychological intensity, or loudness, are correlated, but in no simple manner. Loudness is usually represented in terms of the ratio of higher energies to the threshold energy, thus taking into consideration such psychological relationships as were discussed in the chapter on perception. The unit of loudness is the bel, one-tenth of which is the decibel. One bel is ten times the logarithm of the ratio of any higher energy to the threshold energy — that energy required for bare audibility.

Every vibrating body, except simple instruments like tuning forks, vibrates as a whole and also in parts. The whole vibration determines the fundamental tone. Partial vibrations, or harmonics, while relatively weak, add their contribution to the total sound experience. The sounds generated by partial vibrations are the overtones. Overtones may be picked out, as it were, by resonators, instruments which vibrate at the same frequency and amplify them. Musical instruments differ in the number and loudness of their overtones, the latter depending upon their resonant properties. When overtones are eliminated by sound filters, different musical instruments playing the same note sound much alike, the reason being that they lose their characteristic quality, or timbre.

Two instruments vibrating simultaneously, but differing in frequency, may generate beats and combination tones. Beats are particularly evident when the difference in vibration rate is small. There is one beat per second for every cycle per second difference in vibration rate. Combination tones become evident when the difference in frequency gets above about thirty cycles per second. There are two kinds of combination tones — difference and summation tones. The difference tone may be higher or lower than one of the generating frequencies. Its pitch corresponds to the difference in frequencies. The summation tone is always higher than either generating tone, with a pitch which corresponds to the sum of the frequencies. Beats, difference tones, and summation tones are generated by partial as well as by whole vibrations.

When two or more tones are presented simultaneously, one may mask another. The masking effect may be eliminated by raising the loudness of the masked tone.

Sound waves carried to the eardrum make it vibrate. Vibration is carried to the oval window of the cochlea by three small bones in the middle ear. As the oval window of the cochlea vibrates, liquid in the two outer canals is set in motion. This motion causes a bulge to travel up and down the basilar membrane, the lower part of the middle or cochlear canal. Movement of the basilar membrane causes small hairs in the structures above it to bend. Dendrites connected with these hairs are activated and nerve impulses travel through the cochlear branch of the auditory nerve to the thalamus. Here they make synaptic connection with fibers running to the temporal lobes. Each ear is connected with both temporal lobes.

The basilar membrane responds differentially to different frequencies, its shorter fibers making a maximal response to high frequencies, and its longer fibers a maximal response to low frequencies. This is shown by the cochlear response, an electrical effect produced in the cochlea during tonal stimulation and recorded by electrodes placed on different regions of the basilar membrane.

Although no single nerve fiber can convey more than one thousand impulses per second, the auditory nerve potential reproduces frequencies up to five thousand cycles per second. What happens, apparently, is that every condensation of the sound wave produces a volley of impulses in the auditory nerve. Thus, a vibration of five thousand cycles per second may produce five thousand volleys per second.

The place theory of pitch supposes that each part of the basilar membrane is so attuned that it responds maximally to only one frequency. Thus, the place in the basilar membrane maximally activated, and the place in the brain to which impulses from this maximally activated region go, would determine what pitch was heard. Loudness, according to this theory, is associated with the spread of excitation, a more intense stimulus affecting more of the basilar membrane than a weaker one.

The frequency theory of pitch supposes that the auditory nerve transmits whatever frequency is sent into the ear, the ear itself merely acting like a telephone receiver. This theory could not account for frequencies above one thousand cycles per second unless the volley principle were introduced. But even with volleys in the auditory nerve substituted for impulses in individual fibers, the theory could not account for frequencies above five thousand cycles per second. Loudness may be accounted for in terms of the total number of impulses reaching the brain per second.

The present situation with respect to auditory theory is that a combination of the place and volley principles is required to account for pitch and the more complex aspects of audition. In the last analysis, loudness is correlated with the number of impulses reaching the brain per second.

We judge the distance of sounds through their loudness, complexity, and volume. They are often located in terms of visual cues. When non-auditory cues are removed, we judge the direction of sounds on the basis of different stimulation of the ears.

A sound source equidistant from the ears gives no auditory clue as to its location. When the source is at a distance from one ear different from that from the other, however, the wave (1) reaches the nearer ear first, (2) may lead in phase at the nearer ear, and (3) may be more intense at the nearer ear. These differences enable us to localize the source, but the significance of a particular clue depends on the frequency involved — time being important for localization of noises, phase for localization of tones, and intensity for localization of high tones.

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20 OUR OTHER SENSES

Smell: The question of primary odors; olfactory receptors; olfactory stimulation; olfactory acuity; olfactory adaptation • Taste: The taste receptors • The Skin Senses: The search for structural correlates of cutaneous sensitivity; cutaneous adaptation • Cutaneous Space Perception: Localization; the two-point threshold • Kinesthesis • Static Sensitivity • Organic Sensitivity • Summary

How MANY SENSES do we have in addition to vision and audition? Tradition, going all the way back to Aristotle, says that there are three other senses — *smell* (olfaction), *taste* (gustation), and *touch* (cutaneous sensitivity). It has become rather obvious, however, that we have many more senses than the traditional five. The *common chemical sense,* out of which taste and smell developed, has been retained in various parts of our body, including the moist nonolfactory surface of the nasal cavities. The skin itself mediates four specialized types of sensitivity instead of the traditional one. These are pain, pressure, cold, and warmth. Several senses not even hinted at in the old classifications have also been added to the list. Two of the most important of these are the *muscle sense* (kinesthesis) and the *static sense* (equilibrium). Then there are a number of *organic senses,* of which the most obvious are thirst and hunger. These senses are, in certain respects at least, complexes of forms of sensitivity already mentioned in this paragraph.

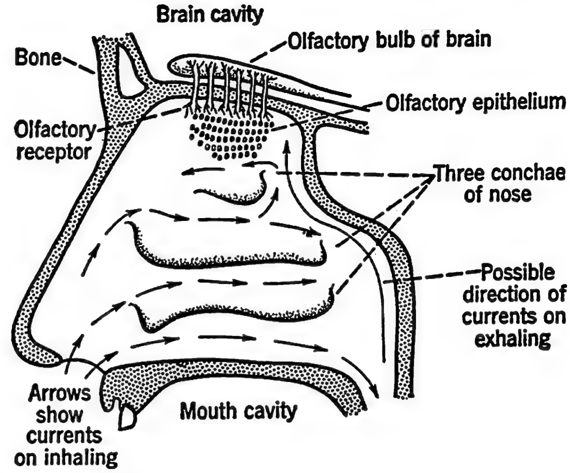
SMELL

Smell is very important in the adjustment of many lower animals. It might be of greater importance in everyday human life than it actually is but for the fact that our visual and auditory senses serve us so well. Like vision and audition, olfaction is a distance sense, informing us of the presence of objects before they touch our body. Its value as a distance sense is evident when gas is leaking or a skunk is in the neighborhood.

Although unimportant as compared with vision and audition, olfactory sensitivity plays a more or less subtle part in many of our experiences and activities. We shall see later that the "taste" of substances is largely smell. Olfaction puts us on guard, too, when foodstuffs are unfit to eat. When food smells good, on the other hand, we eat it with increased relish. Smell may be one factor which enables babies to select appropriate foodstuffs in the cafeteria feeding situation (p. 263). In an experiment with hosiery of exactly the same quality, but lightly scented with narcissus in some cases and unscented in others, six times as many women preferred the narcissus-scented stockings as preferred the others, yet only two out of the two hundred and fifty subjects suspected that any of the stockings had been scented.[1] Perfumers emphasize the potency of their wares in attracting the male to the female, while soap manufacturers warn that annoying odors will prevent us from "making friends and influencing people."

In order to arouse olfactory experience,

substances must be disseminated in gaseous or vaporous form. When the nostrils are completely filled with an odoriferous liquid, no olfactory experience is elicited, but when the liquid is removed and sniffed in the ordinary way, its odor becomes quite apparent. Some substances like ammonia arouse the common chemical sense as well as smell. They irritate the tissues of the nostrils, and sometimes even produce painful effects.



237

A Cross-Section of the Nose

The olfactory receptors can be located in the upper part of this cut-away view of the nasal cavity. (After Parker, as modified by Warren and Carmichael.)

The question of primary odors

If one were to run through a dictionary, checking off every word that represents an odor, he would perhaps find dozens. Most of these would refer to complex odors — that is, to mixtures of simpler odors. Several investigators have sought to discover the irreducible odors — the odors out of which all others might be compounded. Their efforts have resulted in several classifications, no two of which agree. The shortest classification is that of Crocker, an industrial chemist. He finds that he can produce any other odor by mixtures of four or less. The four primary odors, according to this system, are fragrant (musk), acid (vinegar), burnt (roast coffee), and caprylic (goaty or sweaty).[2] The most favored classification among psychologists is that of Henning, which lists six primary odors. These, and a representative of each, are as follows: fragrant (violets), fruity (lemon), spicy (cloves), putrid (bad fish), resinous (pine), and burned (tar). Efforts to correlate these, or any other "primary" odors with particular kinds of molecules, have met with little success.[3] Attempts to correlate primary odors with particular kinds of olfactory receptors have met with no success at all, for all the olfactory receptors look sufficiently alike to prevent classification into types.

Olfactory receptors

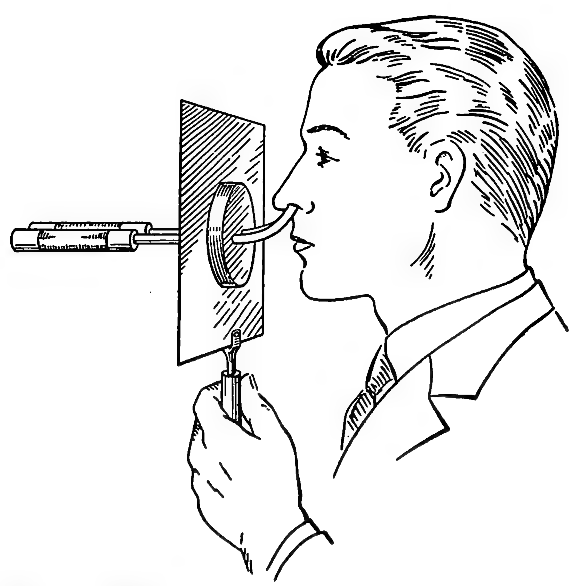
The olfactory receptors are long thread-like structures leading from the *olfactory bulb* down into a small area at the extreme top of the nasal cavities. At their lower end, on which small hairs or cilia appear, the olfactory cells are embedded in the *olfactory epithelium.* Figure 237 shows the location of these structures and their relation to the olfactory bulbs. It also shows that the olfactory epithelium is above the main current of air going from nostrils to lungs. Only eddy currents reach the receptors. This is why sniffing is helpful in identifying an odor.

Nerve fibers run from the upper end of the olfactory bulb. Here they connect with a highly complicated network of neurons. This network is linked by other fibers to various centers in the brain stem and cerebrum.[4]

Olfactory stimulation

How olfactory stimulation occurs is not known. Two possibilities have been suggested. One of these, the traditional theory,

assumes that odorous substances give off gaseous particles which stimulate the olfactory receptors chemically. The other possibility is suggested by the fact that chemists often identify gases in terms of their different absorptions of infra-red (heat) radiation. Our whole body is a source of such radiation. The theory assumes that olfactory receptors radiate a variety of wave-length bands and that different odoriferous vapors, upon entering the nostrils, absorb different bands. If they did so, the respective receptors would lose energy. This heat loss could arouse nerve impulses and the brain might interpret these as odors.[5]



238

A Double Olfactometer

The cylinders, the inside surface of which is exposed, are drawn out until the subject reports the odor. When two are used simultaneously, with the same or a different inner area exposed, one odor may blend, cancel out, or alternate in potency with the other. (After Zwaademaker.)

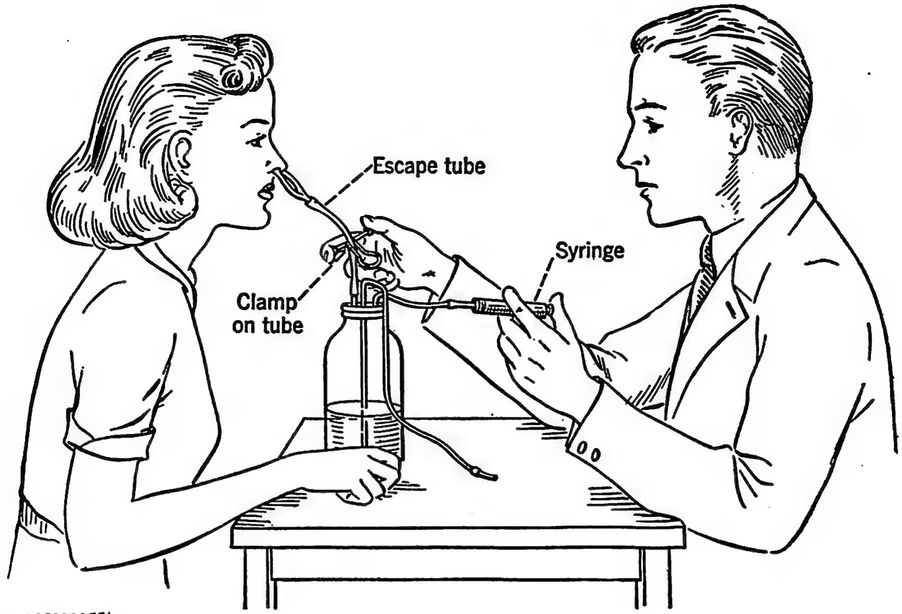
Olfactory acuity

People vary a great deal in their sensitivity to odors. Some have no olfactory sensitivity, an abnormality known as *anosmia.* Moreover, everybody's sensitivity to certain odors is much greater than to others. We smell musk when only minute quantities of the substance are present. Certain other substances have a weak smell, even when we sniff them.

A widely used device for studying olfactory sensitivity is the *olfactometer,* a double form of which is illustrated in Figure 238. The single olfactometer is a calibrated glass tube bent at one end to fit into a nostril. An odor cylinder, covered with glass on the outside, but with its odorous substance exposed on the inside, is slipped over the olfactometer tube so that its end is flush with that of the tube. With this arrangement, no odor is apparent when air is drawn up the tube. But when the cylinder is moved outward, so that its inner surface is exposed to the inspired air, the odor may be smelled. The farther out the tube is moved, the greater the intensity of stimulation. A subject with good sensory acuity requires very little of the surface to be exposed, while one with poor acuity requires a large surface. How far the odor cylinder must be moved out before it can be smelled differs, of course, for different substances.

The double olfactometer makes it possible to present two odors at once and to vary the intensity of each in any desired way. Sometimes the two odors mix; sometimes one odor cancels the other, a phenomenon similar, in a sense, to masking in the field of audition; and sometimes rivalry occurs, the subject smelling one odor and then the other in regular alternation, although he is being simultaneously stimulated by both.

More refined methods of studying odor sensitivity are now coming into clinical and laboratory use. One of these, the blast injection technique, described in Figure 239, was developed by a physician to aid in the location of brain tumors. It serves this purpose because tumors in certain regions give



239

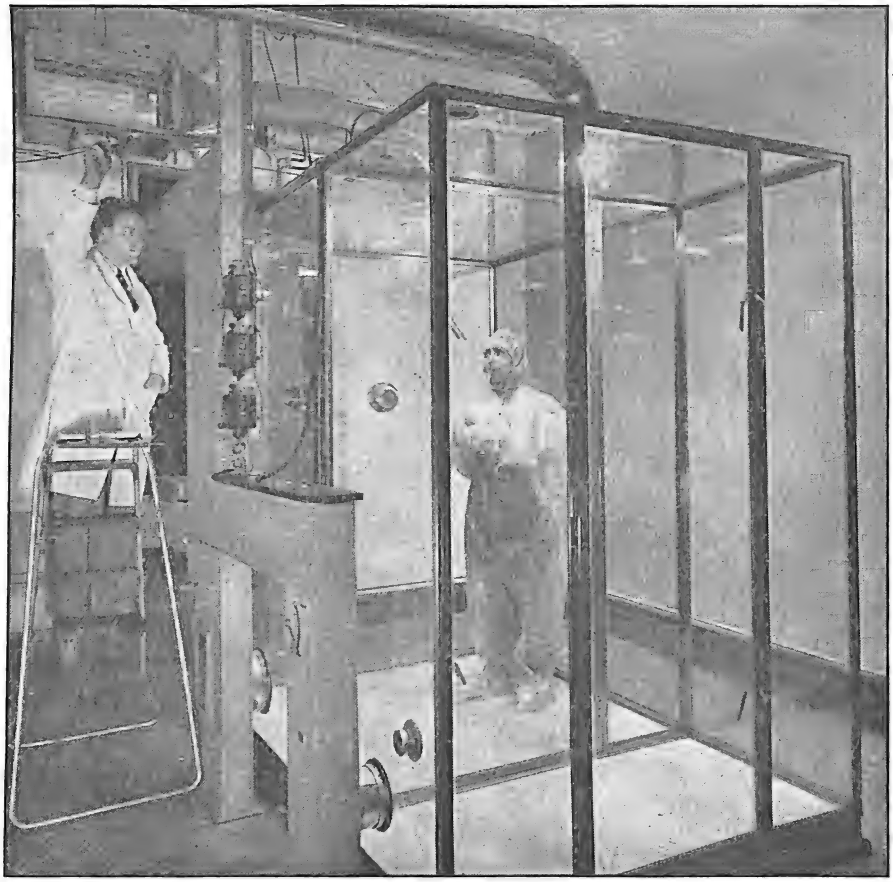
The Blast Injection Technique for Studying Olfactory Sensitivity

A stoppered container with water at any desired level is used. The odoriferous vapor is above the water and its volume may be increased or decreased by changing the water level. The outside glass tube is used in this connection. By using the syringe at the right, the volume of air in excess of the bottle volume is increased as desired, thus also increasing the pressure. When the nose pieces are inserted and the clamp which holds the vapor in check is released, the volume of gas in excess of the bottle volume is forced up the nostrils. The subject tells whether he smells the odor. Volume and pressure are increased until the subject gives a positive report. Volume and pressure may be varied independently — that is to say, the concentration of odorous vapor may be held constant while pressure changes, and vice versa. Recent research, using citrol as the stimulus, suggests that, within certain limits, stimulus effectiveness is related to pressure and not to volume. (After Elsberg and Jerome.)

rise to particular defects in olfactory sensitivity. A further refinement of this technique has enabled a recent investigator to calculate the stimulus intensity in terms of the number of odorous molecules sent into the nostril.[6] At Cornell University a special glass double room (Figure 240) has been developed so that the subject can be studied in a completely controlled odor-free environment. Much as a darkroom shuts out all light extraneous to that needed for the investigation of visual processes, this room eliminates all odors extraneous to those needed in olfactory research. After bathing, the subject enters the anteroom of the olfactorium, puts on an odorless plastic envelope, and enters the stimulus chamber, which has automatic air-purification and control apparatus. From the outside, the experimeter may stimulate his subject by using either the olfactometer or the blast injection technique.[7]

Olfactory adaptation

This phenomenon is well known. Even



240

Double Room of Glass for Studying Sensitivity to Odors

The subject, wearing a special covering of odorless plastic, is shown in the experimental olfactorium developed at Cornell University which is discussed in the text. (From Am. J. Psychol., *July, 1950, p. 434. Photo courtesy of Seagram and Sons.)*

the most obvious odors weaken and finally disappear if we are constantly subjected to the substance that gives rise to them. It is interesting to observe, however, that adaptation to one odor does not necessarily bring adaptation to others. This fact is often the basis of an interesting little demonstration. The instructor mixes two liquids differing in odor, but blending so that the components are indistinguishable when the mixture is smelled. A subject is then given a series of bottles, each of which contains a liquid of different odor. Two of the bottles contain the components of the mixture. The subject's task is to tell which odors produced the mixture. One bottle is sniffed until its odor completely disappears. Then the mixture is sniffed. If the odor to which adaptation has occurred is present in the mixture, the odor of the mixture smells different before and after adaptation. As a matter of fact, the other component than that for which adaptation has occurred will be quite evident. If the odor to which the subject has adapted is not in the mixture, the odor of the mixture will, of course, be unchanged after

adaptation. Sometimes the odor of the mixture changes as it is smelled, adaptation to one component occurring before that to the other.

TASTE

When our taste sensitivity is analyzed, it becomes apparent that much of the "taste" of familiar substances is, in reality, smell. With his nostrils blocked to prevent air from reaching the olfactory receptors, a subject has little or no success in recognizing substances placed on his tongue. Place a drop of lemon juice on his tongue, and he says merely that it is "something sour." A drop of Coca-Cola may elicit the response "bitter-sweet." Quinine is identified merely as bitter. As soon as the nostrils are opened, however, lemon juice is identified as lemon juice, Coca-Cola as Coca-Cola, and quinine as quinine.

Experiments have shown that there are actually but four fundamentally different tastes. These are salt, sour, sweet, and bitter. All true tastes are either salt, sweet, bitter, or combinations of these.

Although taste and smell are the primary contributors to what commonly passes as "taste," other senses sometimes play an important role. The characteristic "feel" of a substance in the mouth may be important. Some substances (like chili and mustard) actually arouse experiences of prick or burn, suggesting that common chemical sensitivity is activated. Other substances merely feel smooth or rough, suggesting cutaneous involvement. It is well known, furthermore, that certain substances "taste" quite different at different temperatures. There is a marked difference, for example, between cold and hot coffee and cold and warm Coca-Cola. The resistance which substances offer to our jaws also brings the kinesthetic sense into play. Toffee might "taste" different if it were so soft as not to require chewing. Celery might also have a different "taste" were it not for the kinesthetic, and even auditory, stimulation involved in chewing it.

It is common knowledge that one taste may blend with or cancel another. Thus, we have bitter-sweet and other blends. On the other hand, sweet substances in sufficient concentration may mask bitter.

Adaptation also occurs. After eating candy, an otherwise sweet-tasting fruit (grapefruit, pineapple, strawberry) may taste excessively sour, apparently because our sensitivity to sweet has been rendered dull by the preceding stimulation.

In order to arouse gustatory sensitivity, substances must be soluble. The reason for this is quite evident when we observe the nature of gustatory receptors. These are below the surface of the tongue and substances must seep down to them before stimulation occurs.

The taste receptors

Illustrated in Figure 241 is the surface of the tongue. The tongue has a number of slight elevations (papillae), the most evident of which are those aligned in the form of a chevron toward the back. These, the *circumvallate papillae,* contain taste cells especially sensitive to bitter. The *fungiform papillae,* evident along the sides and tip of the tongue, also contain taste cells. Those at the tip of the tongue are especially sensitive to sweet, those at the sides to sour, while others scattered all over the tongue except at the center are sensitive to salt. The central part of the tongue toward the front is not sensitive to any gustatory stimuli. Some papillae contain no taste cells.

The taste receptors proper are in *taste buds* at the sides of the circumvallate and fungiform papillae. These buds, because of the peculiar arrangement of their taste cells, were once referred to as "taste onions." The location of taste buds in the circumvallate papillae is illustrated in Figure 242, which also gives some idea of the structure of the

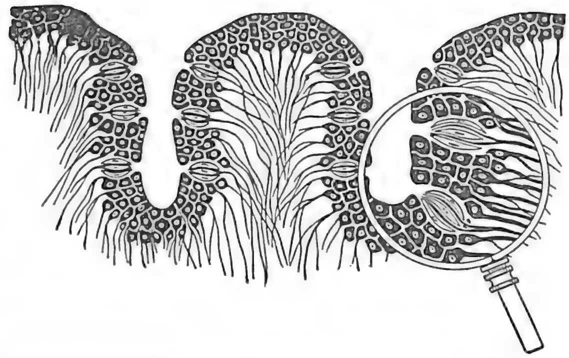
taste cells and their neural connections. Each papilla contains several taste buds, and each of these has several taste cells. We can now see why substances must be in liquid form to stimulate the taste receptors. They must get into the crevices of the papillae, seep into the pore of a taste bud, and then reach the taste cells.

Dendrites which terminate around the base of the taste cells carry impulses back to the nerves shown in Figure 241. The impulses are carried to various parts of the brain stem over three separate nerves. From

241

Papillae of the Tongue

The nerve shown at the upper left connects with the brain stem. It is one of the cranial nerves. (From Warren and Carmichael, after Wenzel.)



242

Diagram to Illustrate the Location and Nature of Taste Buds and Their Taste Cells

Each taste cell has its own nerve fiber, but only one in each taste bud is thus represented here Each bud also has many more cells than can be shown in the diagram.

the thalamus, some of them go to the lower back part of the frontal lobe.

An investigation of electrical potentials in some of the fibers of the gustatory tracts of the cat suggests that acid (sour) placed on the tongue stimulates all fibers. Some of the fibers whose potentials were studied responded only to acid, others responded to acid and salt, but not to sugar or quinine, and still others responded to acid and quinine, but not to sugar and salt. There appear to be at least these three kinds of gustatory fibers. The taste of any particular substance may result from the pattern of discharges in different kinds of fibers rather than discharges in any particular kind of fiber.[8]

THE SKIN SENSES

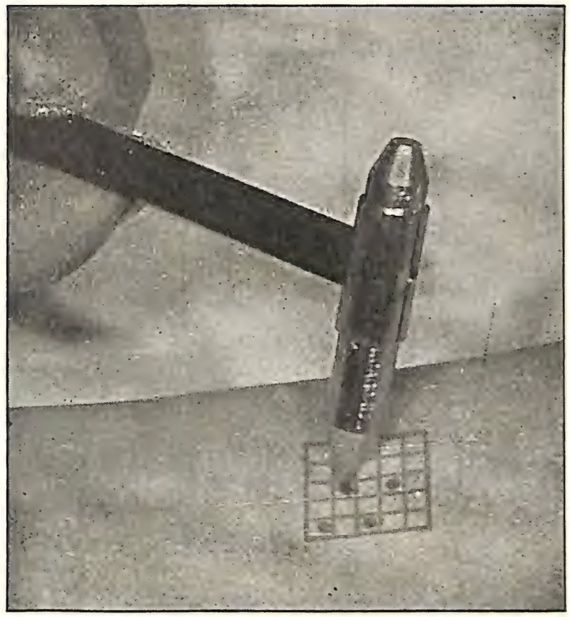
All complex cutaneous experiences, such as itch, burn, roughness, smoothness, stickiness, wetness, and vibration, are reducible to one or more of the following: cold, warm, pain, and pressure. It is now generally accepted that these four are primary skin experiences.

You can easily demonstrate for yourself that there are four distinct skin senses. To

observe them you need only touch point after point on your skin with the cold or warm tip of a nail or similar metal object, with the end of a coarse hair, and with the tip of a needle. As the cold object is applied, some points on the skin will respond with a "flash" of cold, while others merely yield a pressure experience. The points which give the cold experience are called *cold spots.* Some other points, when stimulated with a warm stimulus, will respond with a "flash" of warmth. These are designated *warm spots.* Touching various points on the skin with the end of a coarse hair will arouse pressure experiences. If pressure on the hair is light, "tickle" or contact will often be elicited. Still heavier pressure will arouse what has been called "neutral pressure." As the intensity of stimulation is increased, more of the stimulated points will respond with some sort of pressure experience. Heavy pressure with a blunt object will elicit experiences characterized as "dull pressure." The points which respond to stimulation with a hair are called *pressure spots.* When stimulated with the point of a needle, most points on the skin give a "prick" or "pain" experience. These are called *pain spots.*

Research on cutaneous sensitivity utilizes techniques much more refined than those just described. An area is mapped out (Figure 243) so that the investigator knows beforehand which points are to be stimulated. He may stimulate the same points several times with the same or with different stimuli. The apparatus itself is especially designed to provide constant and measurable stimulation with respect to area, pressure, and temperature. A widely used method of studying pain is to expose a small area of the skin to radiant heat.[9]

Almost all the body surface is thickly covered with pain spots. Pressure spots are also widely distributed, occurring to the "windward" side of hairs and also on hairless regions like the palms and soles. Cold



243

Mapping Skin Sensitivity

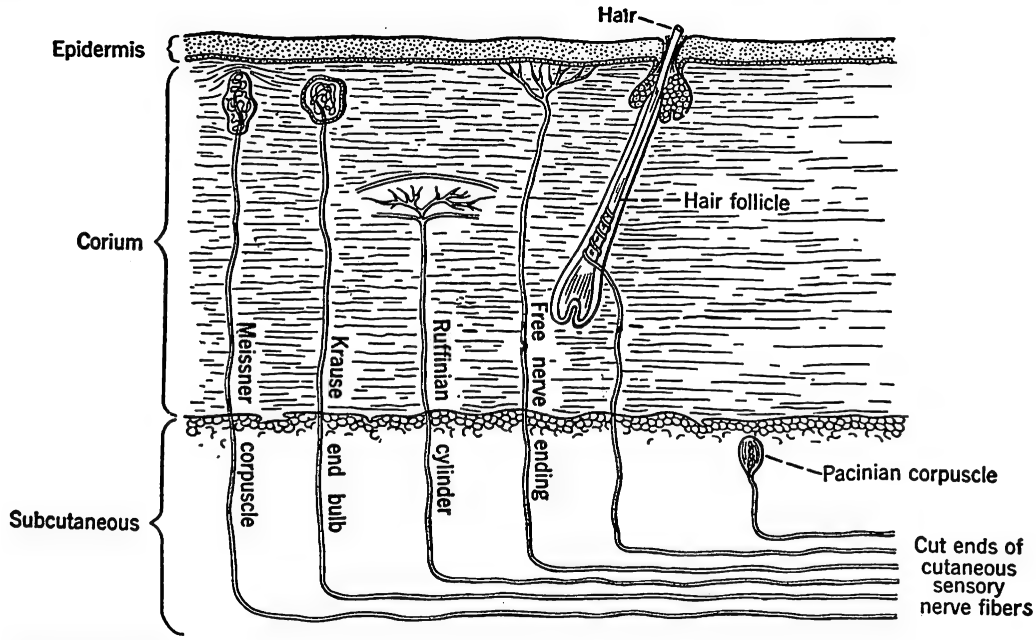
The instrument utilized here is a temperature cylinder, chilled to locate cold and warmed to locate warm spots. In careful research, there is a better control of temperature and pressure than this common laboratory instrument provides.

and warm spots occur less frequently than pain and pressure spots, and a given area of the skin often yields many more cold than warm spots.

When we explore an area of the skin for cold, warm, pressure, and pain spots, and then re-explore it, we find that some spots lack stability. Some that previously yielded cold or warm now fail to do so. It often happens also that what was previously a cold spot is now a warm spot, what was previously a warm spot is now a cold spot, and what was previously only a pressure spot is now a cold or warm spot. Pain spots, on the other hand, are relatively stable.

The search for structural correlates of cutaneous sensitivity

When the cold, warm, pressure, and pain



244

Diagrammatic Representation of Some Cutaneous Structures

Meissner's corpuscles, some free nerve endings, dendrites around hair follicles, and Pacinian corpuscles all respond to pressure, but the latter only to heavy pressure. Other free nerve endings mediate pain sensitivity. The function of the Krause end bulbs and Ruffinian cylinders, once thought to mediate, respectively, cold and warmth sensitivity, is not known. (Modified from Warren and Carmichael.)

spots were discovered, physiologists and psychologists tried to locate correlated receptors. They found that the skin does indeed contain a variety of structures which might serve as specialized receptors. Some of these structures are illustrated in Figure 244.

Free nerve endings are almost everywhere, as also are pain spots. One notable exception is the mucous lining of the cheek, which has no free nerve endings and which fails to yield pain. It appears, therefore, that pain is mediated by free nerve endings. Hair follicles and associated dendrites, appearing to the "windward" side of hairs, where pressure spots also occur, are apparently pressure receptors. Meissner's corpuscles, sometimes referred to in physiology books as "touch corpuscles," are thought to mediate light pressure in hairless regions. Some free nerve endings also respond to pressure. These endings are believed to differ from those which mediate pain in that their fibers are thicker and carry impulses at a greater velocity. Heavy pressure stimulates the subcutaneous tissues, where Pacinian corpuscles are found. Pacinian corpuscles are thus assumed to be receptors for dull pressure.

The structural correlates of temperature sensitivity are not known. Encapsulated end organs lying deep in the skin, free nerve endings, and the microscopic blood vessels (capillaries) which run to every part of the skin, have each been mentioned as possible temperature receptors.

Krause end bulbs were once thought to

be the sole receptors for cold, and Ruffinian cylinders sole receptors for warm. But psychologists located stable cold and warm spots, and had them cut out and sectioned histologically — only to find neither Krause end bulbs nor Ruffinian cylinders. Free nerve endings alone were found.[10]

There is much to be said for a vascular (blood vessel) theory of temperature sensitivity.[11] Every part of the skin is covered with a network of microscopic blood vessels. Free nerve endings terminate in the smooth muscles which surround these vessels and also in neighboring tissues. Lowering the temperature of the skin a sufficient amount leads to constriction of the blood vessels; raising it a sufficient amount leads to dilation. It has therefore been suggested that the pattern of neural excitation sent to the brain by constricting vascular muscles underlies the experience of cold, and that the pattern of excitation sent to the brain by dilating vascular muscles underlies the experience of warmth. How this theory will stand the test of further research remains to be seen.[12]

The cutaneous senses are mediated by nerve fibers which run into the spinal cord or brain stem, depending on the level stimulated. All impulses eventually reach the opposite side of the brain. Impulses from pain and temperature receptors are shunted immediately to the opposite side of the spinal cord. They then travel to the thalamus in two separate nerve tracts. Upon reaching the thalamus, some of these impulses are switched to the somaesthetic area of the parietal lobe.

For reasons not yet understood, cortical stimulation of the somaesthetic area fails to arouse pain sensitivity (see p. 64).

A disease known as *syringomyelia,* which produces a cavity at the center of the spinal cord, or brain stem, usually destroys temperature and pain sensitivity on both sides of the body at the level affected. This is because it destroys fibers which send impulses from each side of the body across to the opposite side of the cord. The individual may first learn of this disease when he cuts or burns his hand and feels no pain or heat. It is interesting to observe, however, that syringomyelia does not necessarily destroy pressure sensitivity. This is because impulses coming in from the pressure receptors travel up an outer region of the cord on the same side. They cross over at a higher level, then proceed to the thalamus and somaesthetic area of the cortex.

Cutaneous adaptation

The pressure and temperature senses show rapid adaptation to stimuli. When constant pressure is applied to a pressure spot, sensitivity gradually decreases until nothing at all is felt. Everyday examples of pressure adaptation are obvious. We cease to feel our clothing soon after putting it on, the ring on our finger might as well be nonexistent as far as pressure sensitivity is concerned, and our glasses are not felt to be pressing on the bridge of our nose. Temperature adaptation is also more or less commonplace. The cold air feels less cold after we have been out of the house a few minutes, and the warm air of the house seems less warm after we have been subjected to it for a while. If one hand has been in very cold water and the other in very warm water, then both are placed in lukewarm water, to one hand (from very cold water) this water seems quite warm and to the other (from very warm water) it seems quite cool. Pain adaptation is questioned. It is true that if you stick a needle in your hand and keep it there, the pain gradually disappears. You may, however, have injured the free nerve ending, rendering it insensitive. An aching tooth, on the other hand, continues to ache until you either have it drugged or have it out.

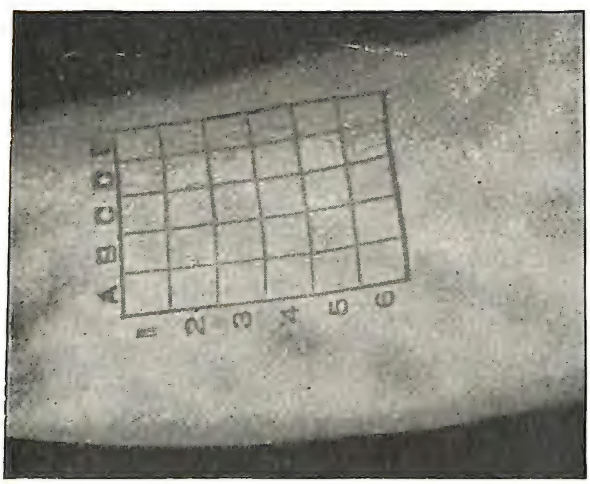
CUTANEOUS SPACE PERCEPTION

Here we have two problems. One of these involves the ability to localize a point that has been stimulated, and the other concerns ability to discriminate between one and two points. The latter is customarily referred to as the *two-point threshold.*

Localization

If somebody touches you anywhere on the body while your eyes are closed, you unhesitatingly name the general region touched. You know, for example, whether the stimulus has been applied to your right or left hand, your forehead or chest, your abdomen or back. You may be able to report the finger touched, or even the joint on a particular finger. The accuracy of such localization is investigated in two general ways.

Tactual-kinesthetic localization. This method requires the subject to make overt localizing movements — in other words, to touch the spot stimulated by placing the point of a stylus or pencil on it. The accuracy of tactual-kinesthetic localization depends on two factors: (1) the subject must know where he has been touched, and (2) he must be able to make muscular reactions of sufficient delicacy to touch the point that he knows has been stimulated.



245 **Diagram for Localizing without Overt Localizing Movements**

This pattern is stamped on the inside forearm and used in localization experiments as described in the text.

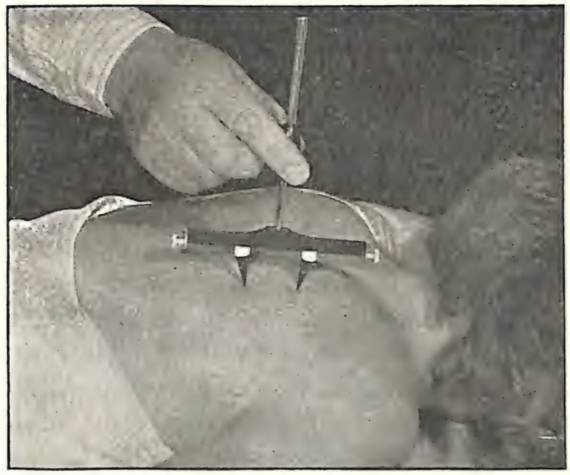
Localization improves a great deal with practice, but the improvement may be due, wholly or in part, to greater accuracy of muscular movement. It does not necessarily follow, in other words, that knowledge of the point stimulated has improved just because the subject can now touch it more accurately. As a matter of fact, the subject often reports from the outset that he knows perfectly well where he has been touched, but that he has difficulty in guiding the pencil point to this spot. If we allow him to do so, he may move the pencil around on the skin until the stimulated spot is reached. Even when such exploration is not permitted, however, the place touched usually differs from the place stimulated by only a centimeter or two. With practice, the error may be reduced to a few millimeters.[13]

Tactual localization without overt localizing movements. The subject may indicate on a photograph of his arm the point just stimulated. This allows him to localize visually and removes the error introduced by trying to guide a pencil point to the stimulated spot. A still better method is to stamp a diagram on the subject's forearm as shown in Figure 245. He is told that the stimulus will always be applied to the center of a square, the particular square differing, in a random order, from trial to trial. The experiment is conducted under low illumination and stimulation is lightly applied, the aim being to leave no impression on the skin which the subject can see. While the subject's eyes are closed, the experimenter touches the center of a square. Thereupon the subject looks at his arm and says in which square (A 1, C 5, or so forth) the stimulus was applied.

The average error of localization under these conditions is about fifteen millimeters for adult subjects. This error is reduced to an average of around twelve millimeters after about five trials, in each of which all points have been stimulated once. With additional practice, some subjects reduce this error.[14]

Localization on other parts of the body is not as accurate as on the hand or forearm. In general, the error of localization decreases as one goes from relatively immobile parts of the body, like the thigh or back, to highly mobile parts, like the fingers.

How do we recognize so accurately the region stimulated? The answer usually given is that each region of the skin has a somewhat different feel and that this *local sign* enables us to recognize it. Much discussion has centered on the question as to whether these signs are inborn or acquired. The fact that tactual localization without overt localizing movements improves with practice suggests that we may learn to locate points of stimulation in terms of their different "feel," but it does not, of course, explain why different regions "feel" different. The question is, however, by no means settled.



246 **Using an Aesthesiometer**

The instrument is being used on the subject's back to determine the two-point threshold as described in the text.

The two-point threshold

How close together may two points of contact be, yet be clearly discriminated as two? The answer depends, primarily, on the region stimulated. If your back is stimulated, sometimes with one point and sometimes with both points of an aesthesiometer, as illustrated in Figure 246, the points will need to be about 70 mm. apart before you can tell whether one or two has stimulated you. On your fingertip, however, the threshold is very low. When the points are two millimeters apart, you will have no difficulty in telling when you have been stimulated by one point and when you have been stimulated by two. Reduce the separation of the points to less than one millimeter, however, and you will not be able to differentiate between application of one point and application of two.

In doing the two-point threshold experiment, it is customary to start with a separation that is easily discriminated and gradually reduce it, or to start with a separation that is not discriminated and gradually increase it. Sometimes both methods are used and the results averaged. Great variation from place to place is observed. For example, one millimeter is the average threshold on the fingertip, five millimeters on the red part of the lips, twenty-three millimeters on the forehead, thirty-one millimeters on the back of the hand, fifty-four millimeters on the back of the neck, and seventy millimeters on the middle of the back.

The two-point threshold, like the error of localizing a single point, is smallest on the most mobile parts of the body. It improves a great deal with practice, but there is probably an irreducible threshold for each re-

gion. In other words, the threshold on the back might be reduced by practice, but it is doubtful whether it could ever be reduced to, let us say, five millimeters. The problem is much like that of visual acuity (pp. 433–434), where the smallest discriminable separation of two points of light depends upon the smallest distance between two receptor fields. The distance between cutaneous receptors is smaller on the tip of the finger than on the middle of the back. Thus, no amount of training could be expected to reduce the two-point threshold of the back to the same threshold found for the fingertip. Subjects who are asked to report upon the two-point threshold must be trained in advance what to call "one" and "two." Sometimes a dumbbell-like figure may be felt which is still one but which the subject realizes is the result of double stimulation.

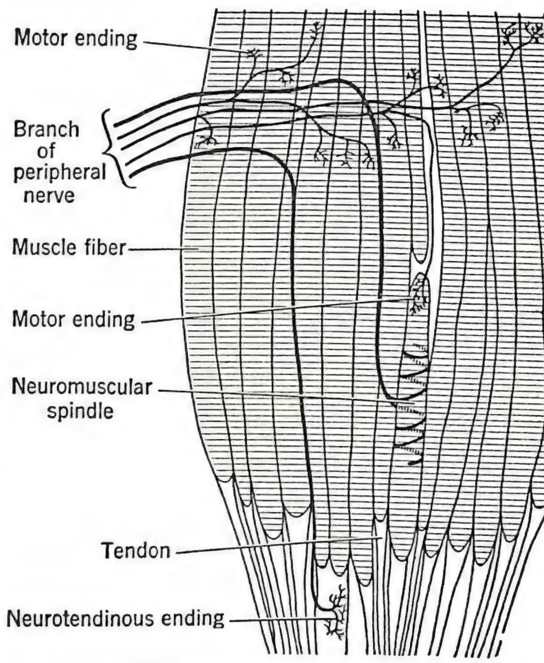
KINESTHESIS

Any normal individual with eyes closed can touch his nose, ear, or any part of his body with a high degree of accuracy. He can move his limbs in various ways and know their position from moment to moment. He can, by lifting them, discern the relative weight of objects. He can go directly to the familiar light switch in complete darkness, walk along the street without paying attention to what his legs are doing, carry on a conversation without thinking of the muscular movements involved, and, if he is an experienced aviator, fly "with the seat of his pants," giving no attention to the manipulation of controls. Likewise, the typist types without looking at or thinking of her fingers, the knitter knits without looking at her knitting needles, and so on. Many of these movements are carried out in the most automatic and stereotyped manner. If we turn our attention to them, they are often disrupted, as in the case of the centipede.

The centipede was happy quite
Until a toad, in fun,
Said, "Pray, which leg goes after which when you begin to run?"
That worked her mind to such a pitch,
She lay distracted in a ditch,
Considering how to run.

The automaticity of such behavior and its independence of vision are made possible by receptors in the muscles, tendons, and joints. Pacinian corpuscles, with which we are already familiar (p. 478), are among these receptors. Others are structures like those illustrated in Figure 247.

The kinesthetic receptors are subjected to pressure, or release of pressure, as our muscles, tendons, and joints are moved. They send impulses to the thalamus and then to



247 **Kinesthetic Receptors in Muscle**

The receptors are the structures connected with the outgoing fibers, indicated by darker lines. (After Denny-Brown, from Gardner's Fundamentals of Neurology. *New York: Saunders, 1947, p. 119.)*

the parietal lobe of the cerebrum, thus informing our brain of the position of our limbs. Incoming impulses are shunted over, in the brain stem or cortex, to motor fibers. These carry impulses back to the muscles, tendons, and joints, thus stimulating further activity. In this way, motor activities act as stimuli for their own rearousal, or for the arousal of other motor activity (see p. 58). This is why kinesthetically controlled habits can proceed so automatically.

We usually pay little attention to kinesthetic experience, but it exists, as anyone may observe for himself merely by contracting and relaxing muscles or moving joints. It has been characterized as strain, ache, pressure, tension, and the like. One can experience kinesthesis in pure form, of course, only when the skin itself has been anesthetized, for movement of any part of the body stimulates the skin as well as the underlying muscles, tendons, and joints.

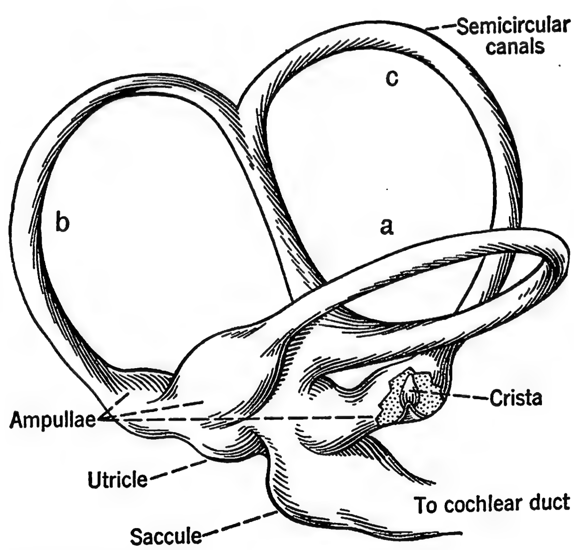
Few people realize their dependence on kinesthesis until they are afflicted with *tabes dorsalis* or observe others so afflicted. The disease follows destruction of the dorsal tracts of the spinal cord or brain stem by syphilis. These tracts carry impulses from our kinesthetic receptors to the thalamus. When they are destroyed at any level, all kinesthetic sensitivity below that level is, in effect, destroyed. Impulses come into the spinal cord or brain stem as before, but they now have no pathway to the brain. The individual thus affected sways considerably when his eyes are closed, cannot lift his foot onto the curb without looking at it, walks with a peculiar (tabetic) gait, and, if the destruction is high in the cord, cannot touch his nose or ear with his eyes closed without extensive exploration. If destruction is in the brain stem, the individual has little success in repeating such words as "electricity" and "episcopal." Phrases like "black bug's blood" are especially difficult. Even ordinary speech becomes "thick" and, in very serious cases, almost unintelligible.

STATIC SENSITIVITY

If stimulation of all other senses were eliminated, static sensitivity would still make it possible for us to discern whether we were right side up or upside down, falling or going up, spinning or standing still, moving forward or backward, or to right or left.

The receptors which mediate static sensitivity are in the nonauditory labyrinth, which, as illustrated in Figure 248, comprises three semicircular canals and two small sac-like chambers (saccule and utricle), known jointly as the *vestibule.* The relation of these structures to the cochlea and other parts of the ear was shown in Figure 228 (p. 457). A liquid known as *endolymph* fills the canals and vestibule.

Each semicircular canal is almost at right angles to the others. There is one canal corresponding to each of the three planes of space. Turning the head in a clockwise or counter-clockwise direction activates canal



248

The Nonauditory Labyrinth

The entire labyrinth is filled with a liquid known as the endolymph. *Its relation to the auditory mechanisms may be seen by referring to page 457.*

a. Canal *b* is activated when the head tips in a forward-backward direction. The remaining canal, *c*, is activated by tilting the head in right-left direction.

At the base of each semicircular canal is a swelling (*ampulla*) in which a small structure containing hairs projects. The hairs of the *crista*, as this structure is called, are bent by a rotary movement of the head. Their bending stimulates associated nerve fibers, which carry impulses thus aroused over the vestibular branch of the auditory nerve (p. 457) to the medulla and cerebellum.

The hairs are activated only by changes in rotary movement. As one suddenly turns his head to the right, the liquid in canal *a* lags, causing the hairs to move to the left, or vice versa. As one suddenly tilts his head forward, the hairs in canal *b* are bent in an upward direction, or vice versa. As one tilts his head to the right, the hairs in canal *c* are bent to the left, or vice versa. When a subject is rotated at a constant speed in a revolving chair, the hair cells of the horizontal canal return to their original position and remain there. The subject then feels that motion has ceased. When slowing down occurs, however, the hairs bend in the same direction as that in which the subject is moving, and he feels that he is moving in the opposite direction.

Rotary movement on the horizontal plane elicits compensatory head and eye movements. These result from reflex neural connections between the semicircular canals, brain, and eyes. The head and eyes drift, as it were, in the direction of movement and then snap back.

Rapid oscillatory eye movements (*nystagmus*) are particularly noticeable after rotation. If you observe someone who has been rotated several times and just stopped, you will notice that his eyes make quick back-and-forth movements. They "drift" in the direction in which he has been moving, then "snap" in the opposite direction. This is known as *post-rotational nystagmus*. Absence of post-rotational nystagmus arouses a suspicion that the semicircular canals or their neural connections are defective. In acrobats, flyers, ballet dancers, and others whose activities stimulate the semicircular canals a great deal over a long period of time, however, post-rotational nystagmus may be absent or of very brief duration. Experiments on animals and human subjects in the laboratory have shown that post-rotational nystagmus may be eliminated by repeated rotation, yet not impair static sensitivity.[15]

The dizziness which follows rotation is also reduced by training in rotation, probably in part, at least, because the eye movements are reduced. This dizziness, as well as nystagmic movements, can easily be induced by rotating an environment of black and white stripes without stimulating the semicircular canals at all (p. 407). Thus, while there is normally a relation between static sensitivity and eye movements, it is not a necessary relation. Under such circumstances as we have described, one kind of activity may occur without the other.

The vestibule, at the base of the semicircular canals, is activated primarily by rectilinear motion — that is to say, motion straight up and down, straight forward or back, or straight to the right or left, in each case without rotation of the head. One form of rectilinear movement is experienced whenever we go up and down in an elevator. Sensitivity to rectilinear movement results from the bending of hairs in the saccule and utricle of the vestibule. These hairs are weighted with calcium particles (*otoliths*). Movement of the body in an up-down, front-back, or right-left direction is associated with a lag in adjustment of otoliths, hence a bending of hairs in the opposite direction. Nerve impulses are aroused which, like those from the semicircular canals, go to the brain via the vestibular branch of the auditory nerve.

Under most conditions of everyday life, our semicircular canals and vestibules are stimulated simultaneously. Impulses which come from the separate structures are co-ordinated in the cerebellum. They play a major role in maintaining the tonus of muscles and the equilibrium of the whole body. It is the nice co-ordination of impulses from these mechanisms that enables the cat to land on its feet, regardless of the position from which it is dropped.

Unusual stimulation of the semicircular canals and vestibule is conducive, in many people, to a malady known, in general, as *motion-sickness.* Those of us who get seasick, airsick, carsick, or swingsick can, at least in part, blame our static mechanisms. Animals and human beings without active labyrinthine mechanisms do not get motion-sick.

Why some people with good labyrinthine mechanisms are susceptible to motion-sickness and others not is an unsolved problem. It is possible, as we shall see, that organic as well as static sensitivity is an important cause of motion-sickness.

Tests of susceptibility to motion-sickness have been utilized in the selection of airborne military personnel. Rear gunners and glider troops are subjected to unusually intense stimulation of the labyrinthine mechanisms, and stimulation involving different directions of rectilinear and rotary motion at the same time. Thus, these, of all airborne personnel, should be least susceptible to airsickness. The tests involved long-con-

249

Some Effects of Rectilinear Motion in the Vertical Plane

The subject is shown before and after being bounced up and down in an elevator-like apparatus designed to study how motion-sickness is related to patterns of motion. After a few minutes of such movement, she perspired, became nauseated, and displayed other signs of motion-sickness. This is from research conducted by Dr. G. R. Wendt of the University of Rochester. (Photographed for Life *by Eric Schaal.* © Time, *Inc.)*

tinued subjection to motion in long swings, elevators, rotating chairs, and the like. Some subjects grew pale, began to perspire, and ended by being ill, but others stood the tests without any signs of sickness. These were, of course, the best prospects for airborne duties.[16] The girl in Figure 249 was subjected to a bouncing up-and-down motion in an elevator especially designed to control the pattern of movement. Her head is marked so that its angle can be observed more readily.

Most people who experience motion-sickness get over it as the trip continues. This probably means that their static mechanisms have in some way become adapted to the unusual movement. After leaving a plane or boat, many people feel that the ground is unsteady and that buildings are swaying in various directions. Such phenomena are often experienced by people susceptible to motion-sickness.

Today the drug dramamine is being widely used to reduce the incidence of motion-sickness. It does this through its effect on the nervous system, not through any influence upon the activity of the labyrinthine receptors.[17]

Deaf-mutes have congenitally defective inner ears (including not only the cochlea but also the vestibular mechanism). It is interesting to note, therefore, that they have little clue as to which way is up when they swim under water with their eyes closed.

ORGANIC SENSITIVITY

Organic sensitivity is sensitivity of the visceral and other internal organs of the body cavity. The viscera include the stomach, intestines, internal sex structures, and kidneys. Nonvisceral inner structures are the throat, lungs, and heart. Activities of the internal organs excite sensory fibers connected with the automatic nervous system, as illustrated on page 351.

Many experiences, most of them rather vague, are associated with the activity of internal structures. Some of these are thirst, hunger, nausea, bladder and intestinal tensions, sexual cravings and thrills, suffocation, and the feeling of fullness. In several instances these feelings have been reduced to varieties of pressure, pain, and temperature sensitivity. Thirst, for example, is associated with dryness in the throat; hunger is associated with pressures and pains resulting from stomach contractions; and nausea is reducible to aches and pains as well as dizziness.

Organic sensitivity is usually stressed in discussions of physiological drives, but it is given relatively little attention from the standpoint of experience. In fact, one will gather from our discussion of hunger, thirst, and sex (pp. 261–268) that these organic activities contribute much more to motivation than to experience.[18]

Some of the nausea and other symptoms associated with motion-sickness are perhaps attributable to visceral disturbances. Sudden upward movement of the body, as in going up in an elevator, on a wave, or on an air current, leads to a lag in the visceral organs. Pulls are thus exerted on the membranes which keep the intestines in position. Pulls are exerted in the opposite direction when the body sinks suddenly. Such pulls, when applied during an abdominal operation, cause nausea and vomiting.[19] It thus appears that visceral tensions may play some part in production of motion-sickness. On the other hand, motion-sickness exists only in individuals with intact labyrinths. Since those without labyrinths are not motion-sick, yet subjected to visceral tensions, such tensions cannot be the sole cause of motion-sickness.

SUMMARY

Smell, like vision and hearing, is a distance sense. It plays a subtle role in everyday life, especially in its contribution to what commonly passes for "taste." The number of primary odors is not known, although the most commonly accepted classification lists six. Olfactory receptors are located high up in the nostrils and are stimulated only by substances in gaseous form. Olfactory acuity, which differs among individuals and for different odorous substances, is measured by means of an olfactometer or by a so-called "blast injector." Double olfactometry demonstrates cancellation by one odor of another, fusion of two odors, and odor rivalry. Olfactory adaptation is the loss of sensitivity as a result of continued exposure to an odor stimulus.

Taste, as such, consists of four primary qualities, namely, salt, sour, sweet, and bitter. The taste receptors are small buds located in the walls of certain of the papillae of the tongue. In order to stimulate cells in the taste buds, substances must be soluble. The tip of the tongue is most sensitive to sweet, the sides to sour, and the back to bitter. Salt arouses a response from all parts of the tongue except in an area in the center toward the front. Most "taste" experiences are blends of the four primary tastes, plus smell, contact, temperature, and common chemical sensitivity. Among the well-known gustatory phenomena are adaptation, mixture, and cancellation.

The primary skin senses, once referred to in combination as the sense of touch, are pressure, pain, cold, and warmth. When the skin is mapped with appropriate stimuli, pressure, pain, cold, and warm "spots" are located. Sensitivity to light pressure is mediated by hair follicles, Meissner's corpuscles, and free nerve endings. Dull pressure involves the deep-lying Pacinian corpuscles. Pain sensitivity is mediated by free nerve endings, those at the end of relatively thin fibers. No specialized receptors for temperature sensitivity have been located, but there is evidence that cold is associated with the pattern of nervous discharge aroused when small blood vessels in the skin contract and that warmth is associated with the pattern of nervous discharge aroused when these small blood vessels dilate. This is the vascular theory of temperature sensitivity. Pressure and temperature adaptation are well known, but the existence of pain adaptation has not been established. Complex cutaneous experiences like vibration, stickiness, dryness, wetness, roughness, and heat are due to simultaneous arousal of two or more of the primary skin senses.

Stimulation of the skin arouses an awareness of the place touched, a characteristic "feel" that has been called the "local sign." One's knowledge of the place touched is usually more accurate than his ability to touch the same spot without use of vision, a feat which calls for kinesthetically controlled skill as well as cutaneous sensitivity. Localization, both with and without overt localizing movements, improves with practice. The two-point threshold, which differs on different parts of the body, is smallest on the most flexible, and largest on the least flexible parts.

Kinesthetic sensitivity comes from activation of receptors in our muscles, tendons, and joints. It is of special interest that, because of these receptors, muscular activities provide the stimuli for their own rearousal or for the arousal of other muscular activities. Kinesthetic sensitivity underlies the automaticity of our well-established habit patterns. Our dependence on kinesthetic sensitivity for everyday activities is illustrated by cases of *tabes dorsalis,* where kinesthetic sensitivity normally associated with certain parts of the body is absent.

The parts affected are lacking in normal co-ordination.

The ability to tell the position of our body in space and the direction of movement comes from the static or equilibratory sense. This sense depends on activities of the labyrinthine mechanisms, namely, the semicircular canals (rotary movement in three planes) and the vestibule (rectilinear movement in three planes). Head and eye movement associated with rotary movement is called nystagmus. Post-rotational optic nystagmus is reduced by practice, yet without interfering with static sensitivity. Motion-sickness is aroused in many people when the labyrinthine mechanisms are unusually stimulated.

Organic sensitivity is that associated with functioning of the internal organs. It includes hunger, thirst, sexual cravings and thrills, and bladder and intestinal tensions. Some organic sensitivity, at least, is reducible to complex patterns of pressure, pain, and temperature sensitivity. Stimulation of internal receptors plays an important part in motivation and emotion. Organic sensitivity may contribute to motion-sickness.

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Part Eight

Individual Differences

In our discussions up to this point there has been little consideration of individual differences. We have focused successively on psychological development, learning, remembering, forgetting, thinking, physiological drives, acquired motives, conflict, emotion, feeling, attending, perceiving, vision, hearing, and the other sensory processes. There are marked individual differences in all these, as we have at times suggested, but emphasis has been on the similarities more than the differences.

We could study individual differences in any of the processes so far considered. Indeed, students of individual differences are sometimes concerned with the variations in particular processes. The literature includes much information on individual differences in memory, speed of reaction, visual acuity, emotionality, and other aspects of behavior. Or we could focus on a particular process and look for sex differences, age differences, racial differences, national differences, regional differences, or occupational differences in the process. Thus we might observe whether, and if so, how much, speed of reaction differs in men compared with women, children compared with adults, Negroes compared with whites, Frenchmen compared with Englishmen, northerners compared with southerners, or skilled compared with unskilled workers. What we shall do, however, is to consider individual differences in three complicated combinations of simpler processes — combinations known as *intelligence, aptitude,* and *personality.*

If we all adjusted to given situations in the same way, the concept of intelligence would never have arisen. If we were equally apt — if we could learn equally well the tasks of everyday life — there would be no concept of aptitude. Likewise, if we all looked alike and acted alike in our relations with others, there would be no concept of personality. The concepts of intelligence, aptitude, and personality are thus grounded in the very obvious fact that people differ. Indeed it is a safe assumption that no two human beings are exactly alike. If they are identical twins, so that we can hardly differentiate between them in terms of their looks, we can still observe differences, although perhaps small ones, in their interests and attitudes and in how they respond to tests and to the situations of everyday life.

Since statistical procedures play a large role in the analysis, interpretation, and scientific utilization of individual differences, we begin with an introduction to statistical procedures. Only elementary procedures and interpretations, which are required for an understanding of the chapters on intelligence, aptitudes, and personality, are considered. Ordinarily it is not important for the beginning student to memorize statistical formulae and to learn to perform statistical analyses. But some familiarity with such formulae and analyses will aid in the appreciation of what is meant by such concepts as central tendency, variability, and correlation.

The chapter on intelligence is designed to provide a survey of typical tests, but more than this, to give the reader an appreciation of what test scores and I.Q.'s mean and how test findings are applied to solve personnel problems in the school and in business and industry. The question of nature and nurture in development of individual differences in intelligence is discussed at length. Racial differences are also considered.

The chapter on aptitudes describes typical aptitude tests and shows what procedures are required for the standardization of such tests. How test results are applied in vocational guidance and vocational selection is discussed. Attention is given to the role played by intelligence and interests. A new development in experimental psychology, the design of equipment in such a way as to capitalize on human aptitudes and increase the efficiency of behavior, is also considered.

Personality, considered in the final chapter, is, in essence, the sum total of every function dealt with in this book. Typical personality tests are sampled, important personality traits are described, some developmental aspects are considered, and the chapter ends with a comparison of normal and abnormal personalities. Special attention is given throughout to the contributions of situational and biological, including glandular, factors.

21 THE STATISTICAL ANALYSIS OF INDIVIDUAL DIFFERENCES

The Frequency Distribution · Measures of Central Tendency: The mode; the median; the mean · Measures of Variability: The range; the standard deviation and probable error; reliability of a mean; reliability of a difference between means · Correlation: Correlation techniques; interpreting coefficients of correlation · Summary

STATISTICAL ANALYSIS, as we pointed out in Chapter 2, is an important aspect of psychological research. In the study of individual differences it is an indispensable tool. As a matter of fact, statistics developed in close relation to the research on individual differences.

This brief chapter is designed to do no more than give an elementary acquaintance with statistical techniques and interpretations. The reader who learns its contents will not be able to do any but the simplest statistical computations, but he will have some appreciation of the meaning of such statistical terms as *frequency distribution curve, normal probability curve, mode, median, mean, range, standard deviation* or *sigma, probable error, standard error, critical ratio,* and *coefficient of correlation* or *r.* This appreciation will facilitate his understanding of literature dealing with the psychology of individual differences.

THE FREQUENCY DISTRIBUTION

Suppose that we give a psychological test to a large group of individuals and wish to know how the scores are distributed. We first arrange the scores into what is known as a *frequency distribution.*

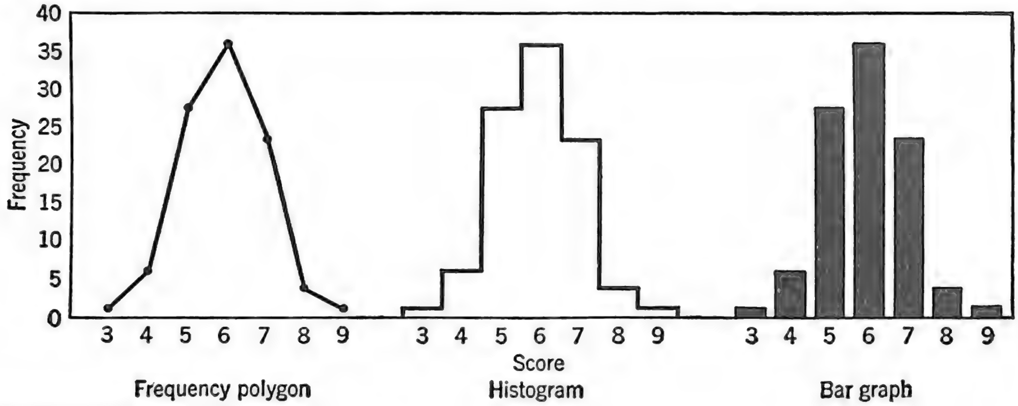
The procedure involved in making a frequency distribution may be illustrated by using scores made by one hundred college students on a test of auditory memory span. Each score represents the longest list of words recalled in correct order after being heard a single time.

4 5 5 5 4 6 6 5 7 6 5 5 5 7 6 5 4 5 4 5
6 5 6 3 7 6 7 6 6 8 7 6 7 6 7 7 6 6 6 6
7 8 6 7 5 5 7 6 6 5 6 7 6 5 7 5 6 7 6 4
8 6 6 5 7 6 5 7 7 8 5 6 5 6 5 7 7 6 6 7
7 6 7 7 6 6 6 5 4 6 5 6 5 5 5 5 7 6 9 5

Observe that the lowest and highest scores are, respectively, 3 and 9. These and the scores between them are arranged in a vertical column. At the side of each score a tally is placed to represent each occurrence of this score. When the tallies are added, the frequency of each score — that is, the number of times it has occurred in the experiment — is obtained.

Score	*Tallies*	*Frequency*
3	𝍷	1
4	𝍸 𝍷	6
5	𝍸 𝍸 𝍸 𝍸 𝍸 𝍷𝍷𝍷	28
6	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍷	36
7	𝍸 𝍸 𝍸 𝍸 𝍷𝍷𝍷𝍷	24
8	𝍷𝍷𝍷𝍷	4
9	𝍷	1
		$N = 100$

With the frequency of each score apparent, it is possible to represent the distribution graphically. As indicated in Figure 250, the graph may be a frequency polygon, a histogram, or a bar diagram. The scores are



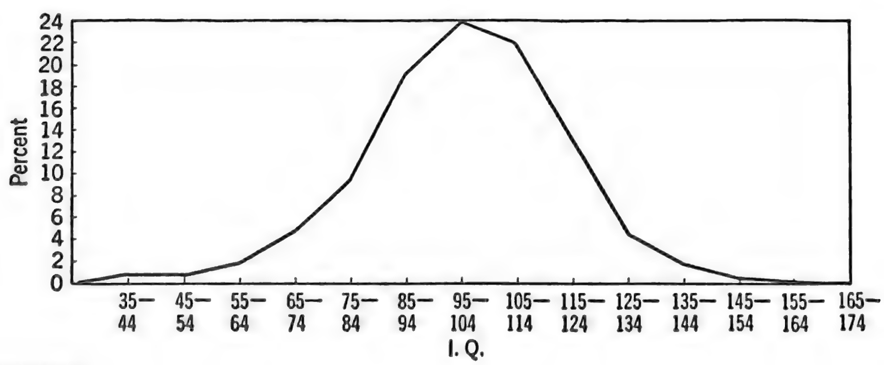
250

Methods of Plotting a Frequency Distribution Curve

arranged along the horizontal axis (abscissa) and the number of times each score occurs is indicated on the vertical axis (ordinate). Since there are one hundred subjects, the ordinate represents both the number and the percentage of subjects making each score. Sometimes a frequency distribution is plotted in terms of the number of subjects making each score, and sometimes in terms of the percentage of subjects making each score.

When the extreme scores differ by a large amount, it is necessary to group them into class intervals. Each point on the abscissa then represents not a particular score but a class of scores. Such a grouping is seen in Figure 251, which shows the per cent of children with I.Q.'s (intelligence quotients) within the class intervals of 35–44.99, 45–54.99, and so on.

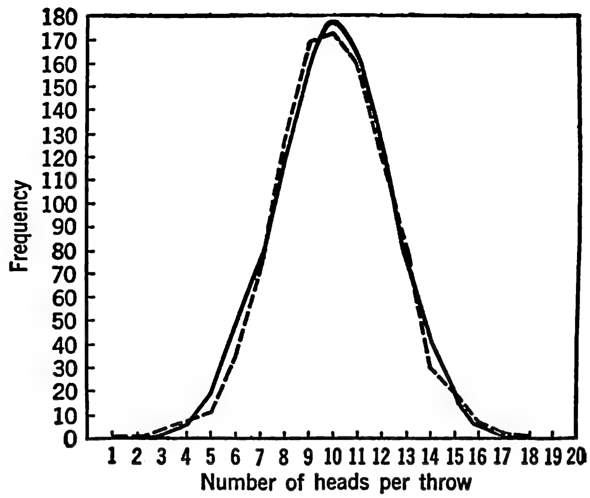
If the number of cases is very large, as in the data of Figure 251, a frequency polygon approaches the shape of a *normal probability* curve like that of Figure 252. The characteristics of such a curve are determined by so



251

Distribution of I.Q.'s in 2904 Children

(From Terman, L. M., and Merrill, M. A., Measuring Intelligence. *Boston: Houghton Mifflin, 1937, p. 37.)*



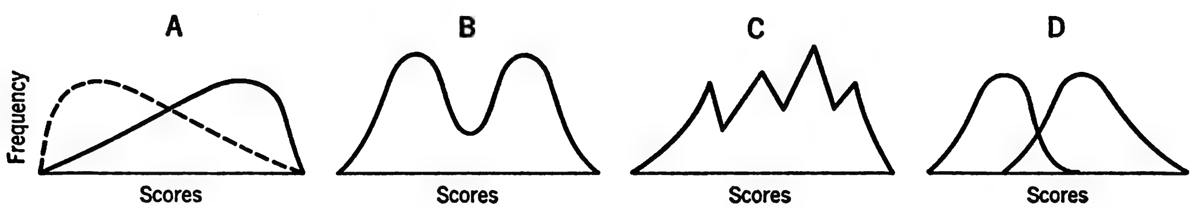
252

The Normal Probability Curve

If everything operated in accordance with chance, tossing 20 pennies (rattling them up in a box and tossing them out on a table) 1000 times would yield the normal probability curve shown in solid print. The number of heads from 0 to 20 appears on the abscissa, and the number of throws in which each number of heads appeared is represented on the ordinate. The curve which appears in broken print is the result of an actual experiment. Instead of the expected average of 10 heads, the average was actually 9.98. If the 20 pennies had been tossed 10,000 instead of 1000 times, the two averages would have been practically identical and the two curves would almost have coincided.

many factors that they are called "chance" factors. It is interesting to note that, when the population tested is very large, most psychological measurements, and such biological factors as height and weight, are distributed in approximate accordance with the normal probability curve.

Because it has definite mathematical characteristics, the normal probability curve is a useful comparative device. Whenever a distribution of measurements closely approximates it, one is justified in using certain statistical devices based upon its characteristics. Some of these will be mentioned shortly. Plotting of frequency distribution curves, however, has several other advantages than determination of how closely the results conform with probability. If the number of individuals making given scores is greater at one end of the distribution than at the other, the amount of *skewness* is apparent. If the curve has a dip in the middle (is *bimodal*), this may indicate that the individuals tested fall into two classes; for example, the dominant and the submissive. Several dips may indicate several types of individuals in the test group. If two quite different groups (two races, male and female, child and adult) have been tested, and a distribution curve plotted for each, the approximate amount of overlapping of scores in the two distributions becomes apparent from the graphs. Types of frequency distribution are illustrated schematically in Figure 253. Skewed, bimodal, and multimodal distributions are quite rare in psychological investigations which involve large randomly selected groups.



253

Types of Frequency Distribution Curves

A, *skewed distributions;* B, *bimodal distribution;* C, *multimodal distribution;* D, *overlapping distributions.*

MEASURES OF CENTRAL TENDENCY

In determining the trend of measurements on the same subject or on different subjects, and in comparing the performance of different groups or of the same group at different times, it is necessary to obtain a measure which represents the typical performance. Measures of central tendency are for this purpose. These measures are the *mode,* the *median,* and the *mean,* or average.

The mode

This is the score of greatest frequency. It may be obtained directly from inspection of the frequency distribution, or a graphic representation of such. For example, the mode in the data of Figure 250 is 6. In Figure 251 it is halfway through the class interval 95–104.99, thus 100.

The median

This score is the middlemost one. If scores are arranged in rank order, one half of them will fall on each side of the median. The median of 9, 10, 11, 12, and 13 is 11, and the median of 5, 6, 7, and 8 is 6.5, halfway between 6 and 7. When the scores repeat themselves, and there are a large number, calculation of the median is much more difficult than these examples would indicate.

The mean

This, otherwise known as the average, is the most widely used measure of central tendency. It is the sum of all scores divided by their number. The total of the scores on memory span (page 493) is 592. This, divided by the number of cases (100), gives a mean memory span of 5.92.

If the data are grouped, as in the frequency table on page 493, each score is multiplied by its frequency, and the total of the products is determined. The sum of the scores times their frequency is then divided by the number of cases. When a large range of scores is involved (as in the data of Figure 251) and the scores must be grouped into class intervals, the midpoint of each interval is multiplied by its frequency to obtain the mean.

In a completely normal distribution the mode, median, and mean are identical. It is very rarely, however, that actual measurements more than approximate a normal distribution. Hence, the three measures of central tendency, although often close together in value, are seldom interchangeable. The nature of a distribution usually indicates which measure is most appropriate for comparative purposes. When a distribution is markedly skewed, for example, the mode and median are better indices of central tendency than is the mean. This is because the mode and median are not affected by extreme scores. The mean, on the other hand, may be greatly affected by extreme scores.

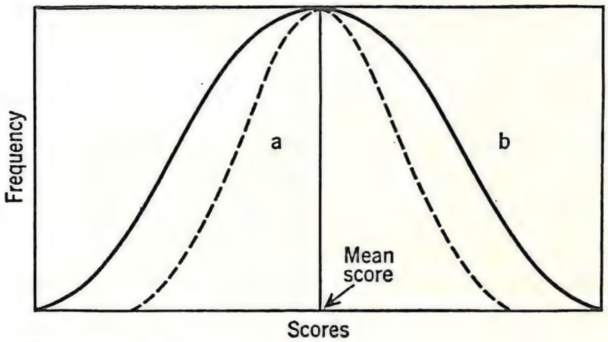
The most widely used measures of variability, as well as certain measures of correlation, require determination of the mean. These measures assume existence of an approximately normal rather than a skewed or bimodal distribution.

MEASURES OF VARIABILITY

The central tendency does not tell all that it is important to know about a distribution. It indicates nothing about the range covered by the measurements nor how they are distributed. For illustrative purposes two different distributions with identical means are represented in Figure 254. It is obvious that an investigator who calculated only the means would be lacking important information concerning these distributions. In *a* the measurements are clustered around the mean, but in *b* they are scattered over a wider range. In *b,* moreover, the frequency of each measurement decreases gradually from the mean to the extreme end of the distribution. In distribution *a* this decrease is more rapid.

The range

The amount of spread in a distribution is



254 **Two Distributions with Identical Means but Differing in Other Characteristics**

indicated by the *range,* which is the smallest score subtracted from the largest score. In the distribution for memory span which was discussed above the range is 9 — 3, or 6.

All that the range indicates is the distance between extreme scores. It tells an investigator nothing about the way in which scores are distributed within this range. It cannot answer such questions as, "What are the chances that a particular individual's score will fall within a certain part of the range?" or, "What per cent of cases is within a certain distance of the mean?"

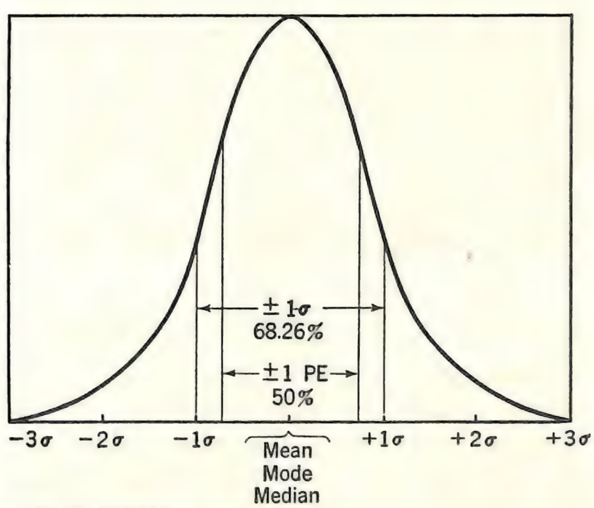
The standard deviation and probable error

The answer to questions like the above is provided by other measures of variability, the most commonly used of which are the *standard deviation of the distribution* (S.D. or σ,[*] which we shall refer to merely as σ), and the *probable error* (P.E.), which may be calculated directly from σ.

The standard deviation and probable error are distances along the abscissa (the score dimension). These measures, the calculation of which will be considered shortly, are not properly used unless there are many scores distributed in approximate accordance with the curve of normal probability. To the degree to which the distribution of scores approximates a normal distribution, to that degree are we justified in speaking of the probable location of given scores or percentages of scores within a given range. This is because, if we mark off 1 σ on each side of the mean of a normal probability curve, 68 per cent of all scores will fall within this range. If we mark off 2 σ on each side of the mean, approximately 95 per cent of the cases will fall within these limits. Practically 100 per cent of the cases will fall within the limits of plus or minus ($\pm$) 3 σ. When 1 P.E. is laid off on each side of the mean, approximately 50 per cent of all scores fall within this range. Practically all scores fall within the limits of $\pm$ 4 P.E. These relations are shown in Figure 255.

It should be clear, then, that if σ is large, the scores are widely scattered from the mean. If it is very small, however, scores are piled up, or concentrated closely around the mean. Distribution *a* in Figure 254, for example, would have a much smaller σ than distribution *b*.

What are the chances that a given score



255 **Normal Probability Curve Showing Sigma and P.E. Ranges**

[*] Sigma.

will fall within $\pm 1\ \sigma$? The answer is 68 in 100. What are the chances that it will fall with $\pm 2\ \sigma$? The answer is about 95 in 100. The chances are approximately 100 in 100 that it will fall with $\pm 3\ \sigma$. Similar information is provided by the P.E., except that $\pm$ 1 P.E. marks off 50 per cent, and $\pm$ 4 P.E. marks off approximately 100 per cent of a distribution.

A formula for calculation of σ from ungrouped data is

$$\sigma = \sqrt{\frac{\Sigma D^2}{N}}$$

where ΣD^2 is the sum of the squared deviations, each deviation being taken from the mean. N refers to the number of cases. Keeping in mind that σ is meaningful only in terms of an approximately normal distribution and that approximation to such a distribution is possible only when there are many randomly selected cases, we may illustrate its calculation by using a few simple figures. Let 5, 8, 9, 13, 14, and 17 represent scores. The sum of these is 66. Since there are 6 cases, the mean is 66/6, or 11. We now obtain the deviation of each score from the mean — that is, 11 — 5, 11 — 8, and so on. Since the deviations are to be squared, there is no need to indicate whether they are in a plus or minus direction from the mean — that is, above or below it. The deviations are respectively, 6, 3, 2, 2, 3, and 6. Squaring these, we have 36, 9, 4, 4, 9, and 36. The sum of the squared deviations is 98. Thus,

$$\sigma = \sqrt{\frac{\Sigma D^2}{N}} = \sqrt{\frac{98}{6}} = \sqrt{16.33} = 4.04 \text{ (approx.)}$$

Calculation of σ from a large number of scores, where the data may have to be grouped, and where the mean may have decimal places, is much more laborious than the simple example that we have given would indicate.

The probable error (P.E.) is calculated by using the formula [1]

$$\text{P.E.} = .6745\ \sigma.$$

The P.E. of our illustrative figures would be .6745 (4.04), or 2.72.

Reliability of a mean

Suppose that we wished to know how well our memory span of 5.92, obtained on a group of one hundred college students, represents the memory span of all (or an infinitely large group) of college students. Since our distribution roughly approximates a normal one, we are able, in terms of the properties of the normal probability curve, to determine how much the mean would be likely to change upon repetition of the experiment. Reliability of a mean is indicated by its *standard error*, σ_M. The formula for σ_M takes into consideration the two chief factors, other than errors of measurement, which would affect the reliability of the mean. One of these is the *number of cases.* Obviously, the larger the group tested, the greater the probability that the obtained mean is representative of all college students. It can be shown that the square root of the number, rather than the number itself, is significant here. One hundred subjects give not 100 times the reliability obtained with one subject, but $\sqrt{100}$, or 10 times. The other factor which influences reliability is the *standard deviation of the distribution,* σ *or* $\sigma_{dist.}$. It will be recalled that σ shows how closely scores cluster around the mean. One can readily see that, if the σ of our memory span results were small, which would mean that scores were closely piled up around the mean, our measure of central tendency would be more likely to be representative of students as a whole than if the scores were widely scattered — that is, if σ were large. The formula which takes cognizance of these two factors is

$$\sigma_M = \frac{\sigma}{\sqrt{N}}$$

where σ represents the standard deviation of the distribution and N the number of cases.

What is σ_M of our data on memory span?

The $\sigma_{dist.}$, not calculated in the preceding discussion, is 1.0. The number of cases is 100. Hence σ_M is 1/10, or .10. We may now say that the mean memory span is 5.92 ± .10. Reference to a table giving the properties of the normal probability curve shows that we are warranted in saying that the chances are 68 in 100 that the true mean (for an infinitely large sample of college students) would not be likely to fluctuate from the obtained mean more than plus or minus .10. In other words, there are 68 chances in 100 that the true mean is between 5.82 and 6.02. Again referring to the characteristics of the normal probability curve, we note that the chances are almost 100 in 100 that the true mean will be within the limits of 5.92 plus or minus three times σ_M, or between 5.62 and 6.22. Precisely why σ_M makes possible such determinations will not be apparent until one has a greater knowledge of statistics than can be presented in an elementary course in psychology. At this stage it is necessary only to get some idea of the kind of information which statistical analysis provides concerning the reliability of the mean.

Reliability of a difference between means

Suppose an investigator wished to discover whether there is a difference in the learning ability of white and Negro children, of males and females, or of rats deprived of vitamin B_1 and rats fed a normal diet. He would apply a comparable test to a large number of comparable individuals from each group. His next step would be to calculate the mean for each group. Suppose that the mean of one group were 95 and that of the other 105. Is this difference of ten points a reliable one? Perhaps in a repetition of this experiment, the difference in means would disappear or even be reversed. Statistical analysis provides a way of determining the probability that the true difference is greater than zero. The measure used is the standard error of the difference between two means, or $\sigma_{Diff.}$. It makes use of σ_M. The reason for this is rather obvious, for the more reliable the two means, the more probable is it that the difference between them is also reliable.

The formula for $\sigma_{Diff.}$ is

$$\sigma_{Diff.} = \sqrt{\sigma^2_{M_1} + \sigma^2_{M_2}}$$

where $\sigma^2_{M_1}$ is the squared standard error of the mean of one distribution and $\sigma^2_{M_2}$ is the squared standard error of the mean of the other.

For purposes of illustration, let us suppose that the standard deviations of the two distributions referred to above have been calculated, and that the standard errors of the means of 95 and 105, respectively, have been found to be .6 and .9. The further calculation is as follows:

$$\begin{aligned}\sigma_{Diff.} &= \sqrt{(.6)^2 + (.9)^2}\\ &= \sqrt{.36 + .81}\\ &= \sqrt{1.17}\\ &= 1.08.\end{aligned}$$

The next step is to work out the ratio of $\sigma_{Diff.}$ to the actual difference. This *critical ratio*, or C.R., is

$$\frac{\text{Diff.}}{\sigma_{Diff.}} = \frac{10}{1.08} = 9.26.$$

Because of the properties of a normal probability curve, a C.R. of 3 or more indicates that the chances are 99.9 in 100 that the difference between the two means is greater than zero. Thus the difference in our example would clearly be a reliable one.[2]

CORRELATION

Correlation technique is one of the most useful of all statistical devices. Among the many kinds of information provided by its application to psychological data are the following four:

(1) The relation between two or more different performances. What is the relation

between scores on an intelligence test and grades in school? In what way, if any, is skill demonstrated in a test of mechanical aptitude related to skill in the workshop? The answer to these and similar questions is of practical and theoretical value. If we can predict an individual's likelihood of success or failure in college before he matriculates, or his possible success or failure in a given occupation before he enters it, we may save him from becoming a misfit. Vocational guidance has this aim. Information concerning correlation of performances also has theoretical significance by offering a means of determining to what degree different kinds of performance (like intelligence test performances) depend upon comparable abilities, or common factors.

(2) The relation between physique and psychological characteristics. What is the relation, if any, between the height of the forehead and intelligence? Is there any relation between tallness and a tendency to dominate others? What relation exists between measurable aspects of physique and measurable aspects of temperament? The answer to such questions is obtained by application of the correlation technique.

(3) The degree to which different groups are alike in psychological traits. Are identical twins more alike than fraternal twins in intelligence, personality, and other characteristics? Are the psychological characteristics of children related to those of their parents? Answers to such questions provide information on the role of heredity and environment in determining psychological characteristics.

(4) Correlation technique is also used to discover the validity and reliability of intelligence, aptitude, and personality tests. A test is valid when it measures what it is said to measure. For example, a test for selecting college scholars is *valid* if scores on the test are correlated highly with college grades. A test is *reliable* if results obtained in measuring different individuals, or the same individuals at different times, are comparable — as different measurements taken with a yardstick, say, are comparable. One method of determining reliability is to test the same individuals twice and correlate the two sets of scores. If the correlation is very high, the test is said to be highly reliable.

An understanding of some of our later discussions will depend upon understanding the fundamental concept of correlation and upon appreciation of the meaning of given coefficients of correlation. A good way to illustrate the nature of correlation is to show how a coefficient is calculated. By selection of simple figures which require a minimum of clerical work for their correlation, one is able to illustrate clearly at the same time both the meaning of correlation and the essential nature of the correlation technique. The chief danger involved in the selection of these figures is that the reader may overlook the conditions which justify the use of correlation techniques. To offset this danger, we shall state at the outset under what conditions use of correlation technique is justifiable. An investigator is justified in correlating data only when: (1) these have been obtained under adequately controlled conditions by means of reliable measuring instruments and (2) they have been obtained in relatively large random samplings of the populations concerned.

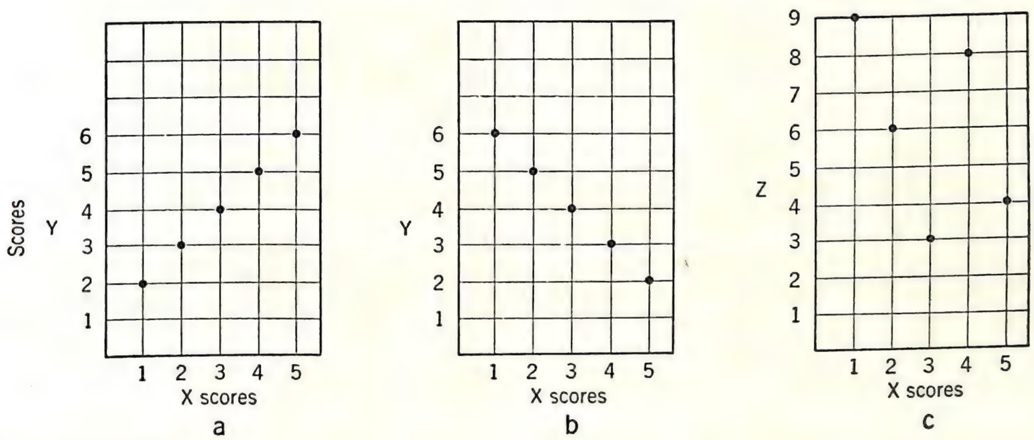
Let us suppose, purely for illustrative purposes, that subjects A, B, C, D, and E were given problems X, Y, and Z to solve. Let us suppose, furthermore, that the number of errors made in learning each problem was as indicated below. Suppose, in other words,

Subjects	*Errors Made in Learning Three Problems*		
	X	Y	Z
A	1	2	9
B	2	3	6
C	3	4	3
D	4	5	8
E	5	6	4

that subject A made only one error before learning problem X, 2 before learning problem Y, and 9 before learning problem Z. One will note immediately that subject A made the lowest number of errors in X and also the lowest number in Y; that subject B made the next to lowest number of errors in X, and the next to lowest number of errors in Y; and so on, down to subject E, who made the greatest number of errors in both X and Y. The correlation here, as we shall see in a moment, is plus 1.00. Were we to have a large number of actual scores obtained as indicated above, and were these arranged in exactly the manner illustrated, the correlation would be perfect and positive. This is exactly what a correlation of 1.00 means. No correlation with actual psychological data is ever as perfect as this. A close approximation to a correlation of 1.00 in psychological material is .98 (for scores on a repetition of the Stanford-Binet Test). But correlations as nearly perfect as this are quite rare.

Suppose, now, that we should have the error scores for X (or Y) in reverse order — that is, with 5 at the top and 1 at the bottom. In other words, suppose that the person who made the smallest number of errors in X made the greatest number in Y, the person who made the next lowest number of errors in X made the next to highest number in Y, and so on. Such an arrangement would give us a perfect negative correlation — a correlation of — 1.00. A perfect negative correlation in psychological investigation rarely, if ever, occurs.

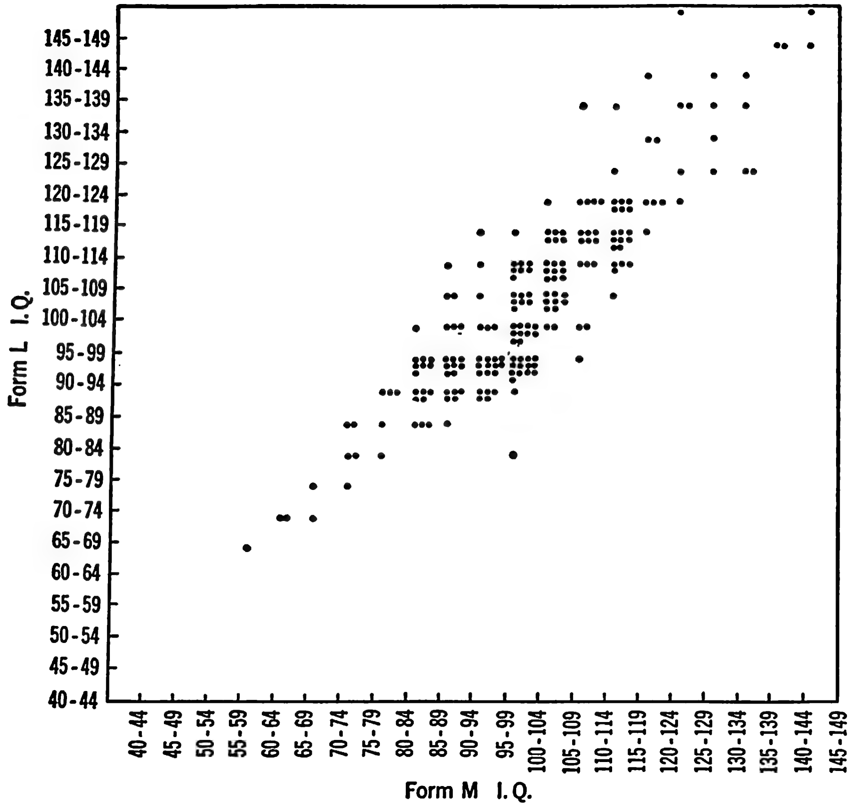
A positive correlation would often become a negative one if the question were differ-



256

Scatter Diagrams Showing Different Degrees of Correlation

In a *is shown the scattergram for the correlation between* X *and* Y. *It is interpreted as follows: Subject* a *made one error on* X *and two errors on* Y; *so we represent him with a point at* X *one and* Y *two. We do this with each subject. When the scores thus arranged slope toward the right as illustrated in* a, *the correlation is a perfect positive one. The diagram shows at a glance that the higher a subject's score in* X *the higher his score in* Y. *If we reverse the figures, assuming that* a, *who made one error on* X, *made 6 on* Y, *and so on, we get the scattergram shown in* b. *This represents a perfect negative correlation. In other words, the fewer the errors made in solving one problem the more there are in solving the other. In* c *the correlation, as one can judge from inspection, is negative, but of doubtful magnitude. We know that it is negative because three of the cases slope definitely to the left as in* b. *Calculation shows that the correlation in* c *is actually —.52.*



257 **Scattergram Showing Relation Between I.Q.'s on Two Forms of the Stanford-Binet Intelligence Test**

Each dot represents the intelligence quotient (I.Q.) of one subject on Form M and his I.Q. on Form L. Each child was of course given one form, then the other. High I.Q.'s on M go with high I.Q.'s on L. Here, r *is obviously positive and high, actually around .90. (From Terman, L. M., and Merrill, M. A.,* Measuring Intelligence. *Boston: Houghton Mifflin, 1937, p. 45.)*

ently framed. For example, the correlation between the personality trait of extraversion and the trait of dominance is about .40. Suppose we should ask, "What is the correlation between extraversion and submissiveness?" With the same data arranged to answer this question, we would now get a correlation of —.40.

The more closely a correlation approaches 1.00, the greater is the relation (positive or negative) between the two things correlated. The meaning of this may be illustrated graphically by using scatter diagrams like those in Figure 256. Here we utilize the selected figures for subjects already mentioned. A scattergram based on actual data is illustrated in Figure 257.

The fact that two or more things are correlated does not, of course, mean that one is necessarily the cause of the other. They might be dependent upon a third factor. In growing children, for example, weight and intelligence are correlated, but intelligence is not the cause of weight, nor weight of intelligence. Height and intelligence are correlated under these circumstances because they both increase with a child's age. We see this when we correlate the intelligence

and weight of children of the same age, for we then obtain a negligible correlation between weight and intelligence.

Cursory inspection of the table or scatter diagram for the X and Z data in our example does not tell us what correlation, if any, exists. We shall calculate this coefficient as well as that for the X–Y data presently.

Correlation techniques

There are several methods of calculating a coefficient of correlation. All give similar results, although, under given conditions, certain of them are more conveniently used than others. The *product-moment* and the *rank-difference* methods are those most widely used. The product-moment method is used when the number of cases is large and distributed in an approximately normal manner. The rank-difference method is not ordinarily used with more than thirty cases.

One formula for the product-moment method is:

$$r = \frac{\Sigma xy}{n\sigma_x\sigma_y}$$

where r is the coefficient of correlation calculated by the product-moment method; x and y, the deviations of X and Y scores from the respective means; n, the number of cases, and σ_x and σ_y the standard deviations, respectively, of the x and y series of deviations. The application of this formula is as follows:

Subjects	*Errors*		*Deviations*			*Calculation of σ_x, σ_y*	
	X	Y	x	y	xy	x^2	y^2
A	1	2	−2	−2	4	4	4
B	2	3	−1	−1	1	1	1
C	3	4	0	0	0	0	0
D	4	5	1	1	1	1	1
E	5	6	2	2	4	4	4
	15	20			$\Sigma xy = 10$	$\Sigma x^2 = 10$	$\Sigma y^2 = 10$

$$M = \frac{15}{5} = 3 \quad M = \frac{20}{5} = 4 \qquad \sigma_x = \sqrt{\frac{10}{5}} \quad \sigma_y = \sqrt{\frac{10}{5}}$$

$$= \sqrt{2} \qquad = \sqrt{2}$$

$$r = \frac{10}{5(\sqrt{2} \times \sqrt{2})} = \frac{10}{(5 \times 2)} = 1.00$$

As already indicated by inspection, r is 1.00. By reversing the figures in either X or Y and following the same procedure, one comes out with — 10/10 or — 1.00. As calculated by this method, the r between X and Z scores is approximately —.52.

We shall illustrate the rank-difference method by correlating the X and Z columns. The formula for calculating a rank-difference coefficient, Rho (ρ), is

$$\rho = 1 - \frac{6\,\Sigma D^2}{N(N^2 - 1)}$$

where ΣD^2 is the sum of the squared differences between the ranks of scores in the two series and N the number of cases. It is first necessary to determine separately the ranking of individuals in each of the performances to be correlated. The computation is as follows:

Subjects	*Errors*		*Ranks*		*D*	D^2
	X	Z	X	Z		
A	1	9	1	5	4	16
B	2	6	2	3	1	1
C	3	3	3	1	2	4
D	4	8	4	4	0	0
E	5	4	5	2	3	9
					$\Sigma D^2 = 30$	

$$1 - \frac{6(30)}{5(25-1)}$$

$$1 - \frac{180}{5(24)}$$

$$1 - \frac{180}{120}$$

$$1 - 1.50$$

$$-.50$$

The coefficients r and ρ are seldom identical, although they are usually similar. The difference occurs because the formula for ρ, unlike that for r, ignores the differences in actual magnitude of the scores, dealing with them merely in terms of rank. Tables have been worked out so that one can read off the value of r for a given value of ρ. The value of r for a ρ of .50 is, for example, .518. If our figures had been for actual data, and based on a sufficient number of cases, we should say that the ρ of —.50 was equivalent to an r of —.518.

Here are some approximate correlations, gathered from specific studies, which utilized specific tests of the phenomena correlated: intelligence test scores of identical twins, .90; intelligence test scores of fraternal twins, .70; group intelligence test performance and college grades, .60; scores on a stylus form of the Maier reasoning test and intelligence test scores, .60; scores on a mechanical aptitude test and rated performance in a mechanical job, .58; intelligence test scores of parents and those of their children, .30; intelligence test scores and performances on a stylus maze, .20; and height of the forehead and intelligence, .00.

Interpreting coefficients of correlation

Before a coefficient of correlation is accepted as indicating a relationship between the variables correlated, it must be evaluated from several angles. One such evaluation is in terms of its reliability. An r is not regarded as reliable unless it is at least four times its probable error.

What does a reliable r of a certain magnitude indicate concerning the variables correlated? Students very frequently, and quite erroneously, think of r as indicating the per cent of relationship between the two variables. Under certain circumstances, it is possible to calculate from r what per cent of dependence of one variable upon another is present. Unless r is nearly 1.00, this per cent is much less than r itself suggests. Suppose we found an r of .50 between intelligence test performance and mathematics grades. It has been calculated that an r of this magnitude indicates 37 per cent dependence of mathematical performance on intelligence, not 50 per cent. According to this manner of interpreting r, an r of .50 means that 37 per cent of the ability required to master mathematics is due to intelligence and 63 per cent to other variables, or that 37 per cent of the factors that contribute to the intelligence test score also contribute to mathematical performance. In order for the dependence to be 50 per cent, r would have to be .707. An r of .95 would indicate only 75 per cent dependence of one variable on the other, and an r of .99, only 88 per cent dependence. An r of 1.00, however, would indicate 100 per cent dependence of one variable on the other.[3]

There are several other ways in which r may be interpreted. One of these considers r from the standpoint of what percentage of improvement in prediction it allows above the prediction made possible without it — in other words, by guessing. Suppose, for example, that we wish to predict how well a student will do in mathematics. The best guess that we can make is that he will do as well as the average student. He may do better work and he may do poorer work, but the best guess we can make is that his work will be average. Suppose, however, that we have a test of intelligence and that performance on this test is correlated .50 with grades in mathematics. How much better can we predict the student's performance in mathematics if we give him the intelligence test and predict in terms of his score? The answer, worked out by calculations which we cannot describe in an elementary discussion, is 13 per cent better. In other words, an r of .50 between intelligence score and mathematics improves our guess that an individual's performance will be average by 13 per cent. Following this manner of interpreting r, an r of .60 is 20 per cent; an r of .80, 40 per cent; an r of .90, 56 per cent; and an r of 1.00, 100 per cent better than a guess.[4]

It should be apparent, therefore, that one must not take a particular r purely on its face value. It is subject to different interpretations, and its "value" varies accordingly.

SUMMARY

We have reviewed statistical procedures and illustrated them with simplified figures which, because they reduce the sheer computation involved in actual statistical analysis, highlight the main features of such analysis. Our goal has been to arouse an appreciation of the value of statistical analysis and to facilitate interpretation of statistical terminology rather than to develop a mastery of statistical techniques.

From what we have presented in this chapter it should be apparent that, once data on individual differences have been accumulated, a frequency distribution enables the investigator to observe the general trend of his findings, and, particularly, to observe how closely they conform to the normal probability curve upon the characteristics of which more refined statistical procedures are frequently based. If the investigator wishes to obtain a more accurate indication of the trend of his findings than is given by the frequency distribution and its graphic representation, he derives measures of central tendency and of variability.

The most obvious and least accurate index of central tendency is the mode, or most frequently occurring score. Other measures of central tendency are the median (middlemost) and the mean (average) scores. We have suggested the manner in which these are derived and also their use in interpreting data on individual differences.

Measures of variability indicate the degree to which scores are scattered from, or concentrated around, the mode, median, or mean. The simplest and least revealing of these is the range, which indicates the degree to which the lowest and the highest measures differ. The standard deviation of the distribution (σ) and probable error (P.E.) receive their interpretation from characteristics of the normal probability curve. They are extremely useful measures of variability. They may be used to mark off the limits, respectively, within which certain percentages of the scores are likely to fall. A small σ or P.E. based upon the mean indicates that scores are piled up near the mean, while a large σ or P.E. reveals that scores are widely scattered from the mean.

We have pointed out that only limited samples of a group (such as Negro or white, male or female), and only limited numbers of measurements on a particular subject (such measures as might indicate his memory span), can be involved in an investigation. For this reason students of individual differences need some index of the reliability of results obtained with particular samples. Such an index is provided by the standard error of the mean (σ_M). This allows us to estimate the chances in one hundred that a particular mean will be likely to change within specified limits. A small σ_M signifies that, were we to repeat the investigation under comparable conditions, the mean obtained would be likely to differ by only a small amount from that already found.

We may also use σ_M to calculate the reliability of a difference between means. The symbol which represents this reliability is the standard error of a difference ($\sigma_{Diff.}$). If the difference between the means were at least three times the $\sigma_{Diff.}$ we could regard the difference as a reliable one. The index used here is the critical ratio (C.R.). A critical ratio of 3 indicates practical certainty that a difference actually exists; in other words, that a difference would continue to be obtained were we to repeat the investigation indefinitely.

Correlation techniques, of which we have illustrated two, provide a means of determining the relation between such variables as, for example, the size of the brain and intelligence, and performance on an intelligence test and success in school. The coefficient of correlation (r) is the most widely used index of correlation; hence, it is re-

ferred to frequently in psychological literature. The coefficient of rank difference correlation (ρ) is used whenever the number of cases is small. The more closely r (or ρ) approximates plus or minus one (± 1) the higher the relationship between the variables correlated. But a coefficient of correlation does not mean per cent of relationship. Percentages of dependence of one variable on another, or of both on some third variable, are calculated from r, but, except when r is very high, these percentages are much lower than r. Coefficients of correlation are also interpreted in terms of the degree to which they improve prediction beyond the guess that performance will be average. Prediction is considered further in Chapter 23, where validation of aptitude tests is discussed.

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22 INTELLIGENCE

What Is Intelligence? • Beginning of Intelligence Tests: Early tests; development of the first "scale" of intelligence; the Revised Binet-Simon tests; the concept of mental age; the intelligence quotient • How Early Can the I.Q. be Determined? • The Stanford-Binet Test: Contents of the test; how the test was standardized; uniform procedure is important; how a child is tested; interpretation of Stanford-Binet I.Q.'s • An Individual Test for Adults • How Constant Is the Relative Level of Test Performance?: Childhood precocity; Terman's gifted children; consistent retardation; I.Q. constancy; changes in the I.Q. • Heredity and Environment Again • The Value of Determining a Child's I.Q. • Performance Tests of Intelligence: Performance tests covering the period from early childhood to maturity • Group Tests: Value of group tests; typical group tests illustrated; interpretation of scores from group tests • Growth of Intelligence • Factors in Intelligence • Summary

Intelligence is a function which we may define as "flexibility" or "versatility" of adjustment.[1] It is a function of living organisms in much the same sense that maneuverability and speed are functions of an airplane.

Why is one plane more maneuverable than another? The answer, obviously, is that it has structures which, for purposes of maneuvering, are better than those of the other. The intelligence of living organisms likewise depends upon their structures, chiefly upon the nature of their response systems.

The airplane analogy is, of course, a crude one. There are many differences between even the most complex inanimate machine and a living organism. One difference which is important in the present connection is that the organism's functions are dependent, not only upon its original structures, but also upon modifications of these which have occurred during its lifetime. The modifications referred to are produced by maturation and learning. Intelligence is thus a function which changes as the organism grows and as the organism is modified by what happens to it.

Intelligence is not a function of any particular set of structures, such as the receptors, the effectors, the nervous system, or any part of the latter, but of the entire organism. This does not mean, however, that all parts of the organism are of equal importance, or that their functions play an equally significant role in intelligence. Our discussion of response systems has already disclosed that functions of the central nervous system predominate in all psychological processes. The cerebral cortex is especially important for what we call intelligent behavior.

WHAT IS INTELLIGENCE?

When organisms at different levels of evolution are observed, it is clear that behavior at one level differs from that at another. The behavior of rats in response to problems in their environment is, for example, much more flexible and much more versatile than the behavior of worms under comparable circumstances. Psychologists

say, therefore, that rats are more intelligent than worms. For similar reasons, they say that man's behavior is much more intelligent than that of monkeys and apes.

On a particular level of evolution, one finds large differences in flexibility of adjustment. This is true even on the worm level.[2] Some worms learn to adjust to new environmental conditions more readily and in a more fitting manner than do others. We may conclude, therefore, that these worms are more intelligent than others.

As we go from worm to man, however, greater individual differences are found in the complex learning processes than in the simpler ones. What might be a good test of learning ability in worms would not be adequate as a test of human learning ability. It would be at or near the limit of learning ability for worms, but elementary for human beings. The genius and the moron would learn it equally well.

Tests which most clearly measure differences in the versatility of human adjustment involve such complex processes as symbolic recall, reasoning, understanding concepts, and learning and using language. These processes are of major significance in human adjustment and tests built around them provide the best measures of human intelligence. We may say, therefore, that, so far as human beings are concerned, *intelligence is flexibility or versatility in the use of symbolic processes.*

Cattell.

BEGINNING OF INTELLIGENCE TESTS

Early tests

Some of the earliest of "mental tests" were devised and used in studies of individual differences among college students.[3] They involved measurements of speed of reaction, sensory keenness, memory, and various other relatively simple psychological processes. Interest was primarily in noting the extent of individual differences. There was no attempt to diagnose the level of intelligence in particular individuals. The tests were put to no practical use.

As early as 1896, however, a French psychologist named Binet, who had been studying psychological processes in school children, suggested the creation of special classes for those children who, because of low intelligence, were unable to progress as fast as others. Eight years later, Binet was asked to serve on a commission formed for the express purpose of discovering which children in the public schools had insufficient intelligence to profit from the usual instruction. Obviously it would be impossible, without doing an injustice to many children, to segregate them on the basis of teachers' judgments. Teachers would almost surely have prejudices and be subjected to various influences from parents and others. They could not be relied upon to make objective judgments. What was needed was a set of objective tests, tests which would measure the intelligence of all children on a strictly comparable basis without the influence of teachers and parents. Binet felt that a graded series of psychological tests could be devised which would, like a metric measuring device, indicate the level or degree of each child's intelligence.

Development of the first "scale" of intelligence

By experimenting with children who were making average progress in school, Binet and a collaborator named Simon determined which of many attention, memory, discrimination, and other tests could be performed by average individuals. He devised a scale comprising thirty tests arranged from the simplest to the most complex. By applying the scale to individuals known to be feebleminded, Binet and Simon were able to obtain norms for these. They determined, in other words, how many tests in the average scale could be done by idiots and other

individuals classified as feebleminded.

By applying their intelligence test to school children, Binet and Simon attempted to discover each child's mental development. If a child of five did only the first nine tests in the scale, the tests performed by a normal three-year-old, it was obviously retarded about two years. If a school child failed to go beyond the first six tests, those passed by idiots, he was designated an idiot. As Binet and Simon put it, they wished "simply to show that it is possible to determine in a precise and truly scientific way the mental level of an intelligence, to compare the level with a normal level, and consequently to determine by how many years a child is retarded." [4]

The Revised Binet-Simon tests

There were many defects in their original scale, hence Binet and Simon eventually devised improved scales.

The chief differences between the first Binet-Simon scale and the final revision were: (1) An increase in the number of items. There were thirty items in the original scale. The final scale contained fifty-four items. (2) An attempt to eliminate all items which would require special schooling for their performance. Binet realized that, if the test were to measure *ability to acquire,* and not merely information, it must comprise items which any normal child, regardless of whether or not he had received training in special fields of knowledge, could be expected to perform. (3) Arrangement of the items in age groupings. There were definite tests for various age levels from three years to adulthood.

The test items to be used at a particular age level were not decided upon in an arbitrary fashion. They were tried out on individuals at different age levels. For illustrative purposes, let us consider the items at age five. These comprised weight discrimination, copying a square, repeating a sentence of ten syllables, counting four pennies, and fitting together the halves of a divided triangle. Each of these items was included at this age level because the average five-year-old could do it.

More specifically, Binet and Simon proceeded somewhat as follows: An item was regarded as adequate for testing five-year-old intelligence if from about 60 to 75 per cent of children at this age were able to perform it accurately, if less than about 60 per cent of four-year-olds could do it correctly, and if it was mastered by more than 75 per cent of six-year-olds. In other words, the item had to be too difficult for the age level below and too easy for the age level above, in order to be included at the intermediate level.

The concept of mental age

In line with their arrangement of the scale into age groupings, Binet and Simon developed the concept of *mental age,* or M.A. A child who could do the five-year tests, but who could not go on to the six-year level, was credited with a mental age of five years. The child of chronological age (C.A.) five who achieved an M.A of five was, of course, regarded as having average or normal intelligence. However, the child with an M.A. of five might actually be ten years old (C.A., ten years). He would, of course, be extremely dull for his age. On the other hand, a child with an M.A. of five and a C.A. of three would be extremely bright. The concept of M.A., therefore, indicated the level of intelligence achieved, but it gave no indication of the brightness or dullness of the individual concerned. A person is not regarded as bright unless we know that his level of performance is better than others of his own age. He is not thought to be dull unless his performance is below that of others of his own age.

The intelligence quotient

It was later suggested that an intelligence

quotient (I.Q.), derived by dividing C.A. into M.A. and multiplying by 100 (to remove decimal places), would be much more meaningful than M.A. alone.[5] Such a quotient would show the rate with which M.A. was increasing in relation to C.A. In a child of average intelligence, whose M.A. equaled the C.A., the I.Q. would be 100, regardless of the actual age. A child of ten years whose M.A. was found to be 10 would have an I.Q. of $10/10 \times 100$, or 100. A child of ten years whose M.A. was 5 would have an I.Q. of $5/10 \times 100$, or 50. This child would be fifty I.Q. points below average. However, a child of ten years with an M.A. of 14 would have an I.Q. of 140 ($14/10 \times 100$) and this would place him forty points above the average child of his own age.

HOW EARLY CAN THE I.Q. BE DETERMINED?

The Binet-Simon tests extended down to the three-year level, as we have seen. A widely used American modification, to be discussed presently, goes down to two years. But there has been an insistent demand, especially from adoption agencies, for tests extending to the first few months of life. This demand for infant tests stems from the desire to make an appropriate placement of babies as early as possible, so that they may have the fullest possible advantages of home life. Unless the intelligence level can be tested, foster parents may adopt babies who will prove later to be feebleminded. A baby's "cuteness" is no index of its level of intelligence. Moreover, to general observation, both normal and feebleminded babies often seem very much alike.

If it is difficult to differentiate the normal from the feebleminded, it is even more difficult to observe which of the non-feebleminded are especially bright or dull. Babies who are going to develop into bright children should be placed with the more intelligent foster parents. The duller children should be placed with foster parents who are not especially bright and who will thus not be too disappointed with their accomplishments.

The need for tests at early age levels has produced several baby tests, but none has so far fulfilled the hopes of those who would like to predict later intelligence while the child is yet an infant. At Northwestern University a new test is being developed.[6] It is largely a recombination and new standardization of certain items from the earlier baby tests. Whether it will do what the others failed to do remains to be seen.*

258

The Ring Test

The baby is placed in the supine position, as illustrated. The examiner then brings the embroidery ring into light contact with the palms, or tips of the fingers of the child's right hand. She does this several times in order to provide sufficient tactual stimulation. After the test with the right hand, the left hand is similarly stimulated. Credit is given if the child's thumb assists in holding the ring. (Photo from Science Illustrated, *Oct., 1948, p. 22.)*

* The earlier tests from which the items for this, *The Northwestern Intelligence Test,* have been taken are those of Gesell, Bühler, Bayley, and Psyche Cattell. Although they have had little pre-

259

Testing Social Response

The examiner approaches, bends over to within a foot of the baby's face, and looks at the baby. Credit is given if the child gazes into the examiner's eyes. If this occurs, the examiner smiles or talks softly. Further credit is given if the baby smiles or coos. Then the examiner moves around to observe whether the child's eyes will follow. If they do so, more credit is obtained. Then the examiner leans over and scolds "You are a very bad baby." Frowning, getting tense or crying brings the baby further credit. The examiner dons a mask. Credit is received by the babies who change facial expression upon looking at the mask. (Photo from Science Illustrated, *Oct., 1948, p. 23.)*

This test allows for calculation of I.Q.'s as early as one month. Follow-up data with older children tested as babies are as yet inadequate, but they suggest that a close relation may yet be found between early and later I.Q.'s.

The infant tests are all alike in emphasizing sensory and motor development. Some items from the Northwestern Intelligence Test for infants four to twelve weeks old will serve to illustrate this point. The baby is tested to see whether he compensates his head when pulled to a sitting position, whether he holds his head erect momentarily, whether he holds his head steady, whether he closes his fingers over a rattle handle, whether he uses his thumb in grasping a ring (Figure 258), whether he investigates a piece of paper over his face, whether he blinks or averts his eyes in response to a flashlight, whether he reacts to the ringing of a bell, whether his eyes remain on a cube for at least five seconds, and so on. Some items, which may turn out to be more prog-

dictive value, from the standpoint of estimating later intelligence, these tests have been useful in the study of behavioral development, especiallv sensory and motor, during the period of infancy.

nostic than such motor and sensory items as we have just mentioned, are those which involve social responses (Figure 259) and memory. Some social items are gazing into the examiner's eyes, changing facial expression when the examiner changes her tone of voice, changing facial expression when the tester puts on a mask, and attending while the examiner is talking. A memory test is looking for a face that has just disappeared. Response to an absent face is, of course, delayed reaction. The reader may recall our illustration (p. 203) of another such baby-test item.

As in the Binet-Simon tests, the items of the Northwestern test are graded in terms of the per cent passing them. The average number of tests passed by babies of six weeks, for example, is 25. Thus a particular infant of six weeks would be regarded as bright if he made a significantly higher score than 25 and dull if he made a significantly lower score than 25. A baby of four weeks who made this score would be rated relatively bright, whereas one of eight weeks who did no better would be rated relatively dull.

The reason that such tests have so far failed to predict later intelligence is their great dependence upon motor development. This is not correlated very highly with intelligence as measured by tests which, like the Binet-Simon, place a great deal of dependence upon facility in understanding and utilizing language.[7] The test now to be considered is the most widely used American Standardization of the Binet-Simon tests.

THE STANFORD-BINET TEST

The Stanford-Binet Test was developed along lines laid down by Binet and Simon in their final scales. It is called the "Stanford" Binet because Professor Terman and other psychologists at Stanford University revised it. The latest revision appeared in 1937.

Contents of the test

The 1937 Revision of the Stanford-Binet Test has items arranged for age levels from two to fourteen years.[8] There are both yearly and half-yearly tests from two to four years and yearly tests from four to fourteen. In addition, there are four groups of tests for adults — one for average adults and three for superior adults. Six items are included in all but the adult levels. The number of items at the adult levels ranges from six to eight. Some of the test materials are illustrated in Figure 260. An idea of the nature of items at widely different age levels may be gained by examining the following selection.

Items Illustrating the Stanford-Binet Test

Year II
1. Three-hole formboard. (Places forms in holes.)
2. Identifying objects. (Points to each as it is named.)
3. Identifying parts of body. (Indicates named parts of doll.)
4. Block building: Tower. (Builds tower from model after demonstration.)
5. Picture vocabulary. (Names common objects.)
6. Word combinations. (Spontaneous word combinations noted.)

Year VIII
1. Vocabulary. (Defines eight words from list.)
2. Memory for stories.
3. Verbal absurdities. (Tells what is foolish about statements.)
4. Similarities and differences. (Tells how certain objects are alike.)
5. Comprehension. (What to do when . . .)
6. Memory for sentences.

Average adult
1. Vocabulary. (Defines twenty words from list.)
2. Codes. (Writes message in code provided.)
3. Differences between abstract words.
4. Arithmetical reasoning.

260

Some of the Materials Used in Administering the Stanford-Binet Test

A simple formboard is seen at the top. Some of the other items are to be named. Some are used in more complex tests, as when one is covered and the child is asked to recall what it is. The strictly verbal material used at higher age levels and including the vocabulary list is of course not shown here.

5. Proverbs. (Tells their meaning.)
6. Ingenuity. (Reasoning test.)
7. Memory for sentences.
8. Reconciliation of opposites. (Tells in what respects certain opposites are alike.)

How the test was standardized

The procedure followed in standardizing the Stanford-Binet Test of intelligence is similar to that followed in standardizing any good test of individual differences in psychological functions. In general, standardization requires that appropriate items be selected; that a uniform procedure for their administration and scoring be worked out; that they be given a preliminary tryout on a representative sampling of the population on which they are eventually to be used; and that age norms and other relevant norms or standards be determined.

Many items were taken over from the earlier test, itself based upon the Binet-Simon scales. Some were borrowed from other tests. A survey of literature of child psychology suggested a number of items. Others were included on the basis of experiments carried out by graduate students in the Stanford University psychological laboratory. In this preliminary selection of items, the following criteria were used: (1) the test must be interesting to the child, so much so that he will regard it as a game; (2) the items must not require special schooling; (3) they must really call for use of intelligence; and (4) they must require no more than a reasonable amount of time for their performance and scoring.

Thousands of possible items were gathered before the real problem of sifting was undertaken. The most promising items from all

these were still too numerous. However, a large number of items were tried out in one thousand school- and five hundred preschool children in the neighborhood of Stanford University. Some of the items were found too easy and others too difficult. Since they failed to differentiate, these items were dropped. After a sifting had taken place on this basis, there were enough additional items to form two comparable tentative intelligence scales. The items in these two provisional scales were arranged into age groupings upon the basis of the results actually obtained in using them. For example, those which average seven-year-olds successfully performed, but which were too difficult for six-year-olds and too easy for eight-year-olds, were placed at the seven-year level.

A uniform procedure for the administration and scoring of each item was carefully worked out, again on the basis of results obtained in the preliminary administration. Instructions were worded to avoid ambiguity and suggestions concerning the correct response. Seven psychologists who were to give the test in its final standardization were trained for two months, so that, in the administration and scoring of the provisional scale, they would follow, as closely as possible, an unvarying procedure.

The provisional forms of the Stanford-Binet Test were administered by the trained examiners to approximately three thousand individuals ranging in age from two to eighteen years. These individuals, from seventeen different communities in eleven states, were selected as representatives of the entire country. Their schools were judged to be average ones. Selection of the persons to be tested was such that they proportionally represented the various socio-economic groups (professional, skilled labor, unskilled labor, and the like). All were American-born whites.

The examiners calculated the average scores made by age and sex groups. Average M.A.'s attained by groups of various chronological ages were found to be close to the chronological age. The average I.Q.'s, therefore, were approximately 100 at each age level. Moreover, the average I.Q. of boys and girls was approximately the same. Only a few slight changes in the test were suggested by the tryout. We have already (p. 494) shown how the I.Q.'s were distributed in a group of 2904 children.

Uniform procedure is important

Uniform procedure is of extreme importance in standardization. It is just as important in administration by any tester. Those who administer the Stanford-Binet Test usually receive, in college or in graduate school, a course of instruction which familiarizes them with the theory and technique of testing. They learn the various items of the test, how to administer them correctly, and how to score and interpret the results. They are, in addition, usually required to administer from twenty-five to fifty tests under critical supervision before placing any reliance upon the results of their testing.

The importance of standardization in administration of tests may be illustrated by the following hypothetical case. Suppose one tester says to the child who is to be tested, "Well, Johnny, today we are going to see how bright you are"; while another says, "Well, Johnny, how would you like to play some games?" One may see quite readily that the attitude of Johnny might be quite different in one case from that in the other. Suppose, moreover, that an item in the test requires the child to tell how he would find a ball if it were lost in a field. Without standardized administration of the item, one tester might say, "How would you find your ball?" The other might say, "What system would you follow in finding your ball?" A systematic procedure would be suggested in the latter case and not in the former. If a systematic procedure were required in order

to obtain credit for this item, one child might pass and the other fail, the scores differing because there was a deviation in administration of the test item, not because of a difference in intelligence.

Both in standardizing tests and in administering their final form, one is, in a sense, performing an experiment. The test is the independent variable, the child's performance the dependent variable, and the standardized procedure the set of controls or constants.

What we have said about the administration of tests applies to their scoring. The scoring is as objective as possible. This means that every person who scores a test uses the same criteria. Such criteria are set up beforehand, and testers are trained to apply them correctly.

How a child is tested

The tester places little reliance on the I.Q. obtained unless the child being tested is at his ease. Those who administer the Stanford-Binet and other individual tests of intelligence are instructed to win the child's confidence and attempt to overcome any evident nervousness or timidity. One way in which this may be accomplished with young children is to suggest that the tester and the child are playing a game. The tester also encourages the child by praising his performance. Such encouragement is

261

A Six-Year-Old Does the Bead-Pattern Item from the Stanford-Binet Test

In order to pass this item the child must, as this boy has done, duplicate the pattern threaded by the tester. Clearly, a friendly relationship exists here between the tester and subject. The child is completely at ease, and appears absorbed and pleased with his activity in the testing procedure. (Photo courtesy of City College Educational Clinic.)

given, whether the responses are right or wrong. The child is never told, "That is wrong." He is encouraged by such comments as, "That's very good, now we'll try the next one." A typical relationship between tester and child is shown in Figure 261.

After the child is at his ease, the tester administers the test items in accordance with established procedure. If the child is judged to be far below normal, the tester begins with test items far below those designed for the actual C.A. level. Should the child appear average, however, the first items administered are those for the children one year below the actual C.A. Take a child of nine years and two months, for example. If he appears about normal or above, he is given the items for year VIII. If he passes the six items at this level, he is next given those for year IX. Should he pass these, the child is next given the items for year X. Here, perhaps, he passes only four of the six tests. At the next level, year XI, he succeeds in doing two tests. The child does one test, say, at the XII level. Let us suppose, furthermore, that he fails to perform any test at the thirteen-year level. The test terminates at this point. The child's I.Q. is then calculated as follows:

		M.A. in months
Year IX	All tests passed	108
Year X	Four tests passed	8
Year XI	Two tests passed	4
Year XII	One test passed	2
Year XIII	All tests failed	0
		122 months

$$\text{I.Q.} = \frac{\text{M.A.}}{\text{C.A.}} \times 100 = \frac{122}{110} \times 100 = 110.9, \text{ or } 111$$

Observe that the child is credited with all the months of mental age prior to the highest level at which he passes all items. This is called the basal age. In the present example, it is nine years, or 108 months. He is then credited with an additional two months for each item passed between this age and the level on which he fails all items. The credit per item is two months because there are six items at each level. In our example, the child gets an additional eight months credit at year X, an additional four at year XI, and an additional two at year XII.

The psychologist is not satisfied to calculate the I.Q. and stop there. He notes the various items passed and those failed. Moreover, he observes the "quality" of the various responses. In this way, he makes an inventory of the strong and the weak functions which combine to yield the child's particular score. For diagnostic purposes, this analysis is often much more useful than the mere determination of an I.Q.*

Interpretation of Stanford-Binet I.Q.'s

The I.Q.'s obtained with tests other than the Stanford-Binet, although they are based upon the same fundamental concepts as those involved in this test, are not always comparable with Stanford-Binet I.Q.'s. It is customary, therefore, to designate the test with which the I.Q. was determined.

M.A. and I.Q. are comparative rather than absolute measures of intelligence. The reason for designating I.Q.'s as "Stanford-Binet I.Q.'s" is that their significance is purely comparative. When we say, for example, that the above-mentioned child has an M.A. of 122 months, we are pointing out merely that he has reached a level of intelligence roughly equivalent to that reached by chil-

* In calculating I.Q.'s for individuals older than thirteen, one does not divide the M.A. by the actual C.A., but by a figure which has been decided upon in the light of standardization results. The divisor increases gradually from 13 to 15. When the individual is fifteen years of age or over, the divisor is always 15. The reason for disregarding actual C.A. at the upper age levels is that yearly increments in M.A., as determined by the Stanford-Binet Test, gradually decrease after the age of thirteen years. From the age of fifteen years on, there is no further increase in M.A. with an increase in C.A. The significance of this will receive further consideration later.

dren of C.A. 122 months in the group on which the test was standardized. We are justified in saying that he has a particular M.A. or I.Q. only when: (1) he has had educational opportunities comparable with those of the children who formed the standardization group; (2) the standardized procedure of administration and scoring has been followed; (3) he has been at his ease and has co-operated to the best of his ability while taking the test; and (4) he has suffered no physical or social handicaps (glandular defects, home conflicts, and so on) which might have prevented him from making the best possible use of his educational opportunities.

We see, therefore, that the value of an M.A. or an I.Q. is relative rather than absolute. It is relative to the standardization group and the conditions under which this group was tested. We shall have something to say later about the question of whether the I.Q. indicates anything about native capacity for intelligent behavior.

Keeping the above facts in mind, we can proceed to a discussion of the meaning of Stanford-Binet I.Q.'s. When a child is said to have an I.Q. of 111, this indicates merely that the rate at which his M.A. increases is slightly in advance of the rate at which his C.A. increases. If his I.Q. remains at 111, or thereabouts, year after year, we are justified in concluding that he remains at the same level above the average of other children of his age, or that his initial advantage is maintained year after year. It does not mean, however, that his intelligence remains the same year after year. Only the *rate* of mental growth is constant when the I.Q. is constant.

From our previous discussion of the I.Q., it will be recalled that, when M.A. and C.A. increase at the same rate, the I.Q. is 100. An I.Q. below 100 indicates that M.A. is increasing more slowly than C.A. The amount by which the I.Q. exceeds 100 is a rough index of the degree of mental precocity; the amount by which it fails to reach 100, a rough index of the degree of mental retardation. If the individual's I.Q. remains the same at yearly age levels, we can say that he maintains his relative position in the group.

It is customary to refer to levels of intelligence in terms of I.Q. ranges as indicated in Table 8.

TABLE 8. LEVELS OF INTELLIGENCE IN TERMS OF STANFORD-BINET I.Q. RANGES

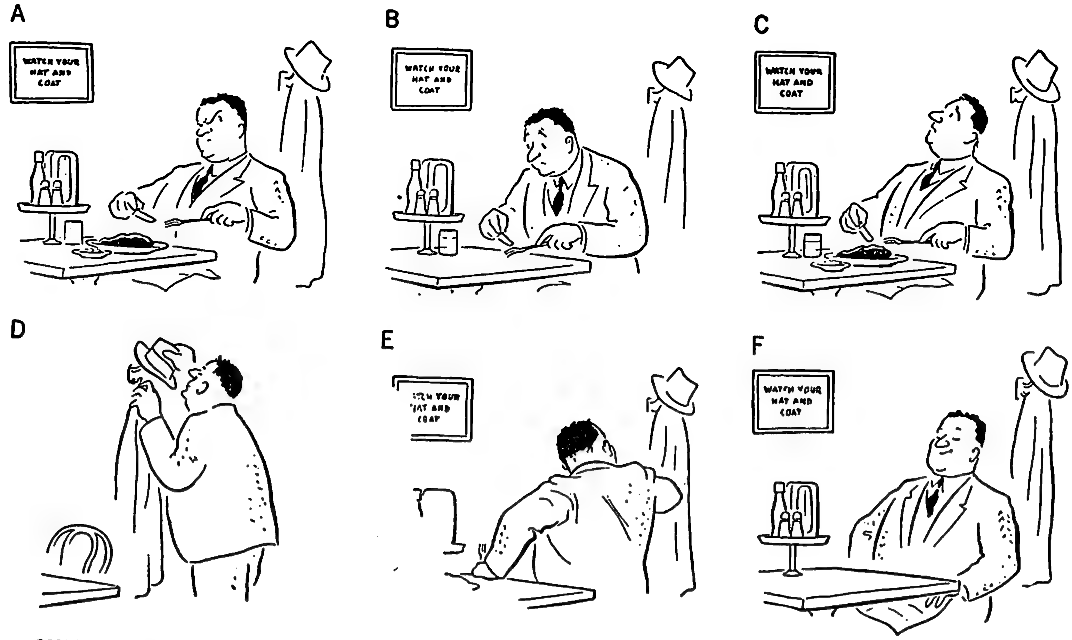
	I.Q. Range
Idiot	0– 25
Imbecile	25– 50
Moron	50– 70
Borderline	70– 80
Low normal	80– 90
Normal	90–110
Superior	110–120
Very superior	120–140
Near genius	140 and over

AN INDIVIDUAL TEST FOR ADULTS

Although the Stanford-Binet Test goes up to the adult level, it has been found most useful when administered to children. A test that is somewhat similar in certain respects has been designed especially for adults. This is the Wechsler-Bellevue Scale, developed by Dr. David Wechsler of Bellevue Psychiatric Hospital and widely used to test the intelligence of both normal and mentally ill adults.[9]

The Wechsler-Bellevue Scale,* like the tests already discussed, is an individual test, i.e., it is administered to one person at a time. Some of the tests in the scale are *verbal*, dealing with general information, comprehension, arithmetic, memory for digits, and vocabulary. Others of the tests do not depend to a great extent upon

* This should not be confused with the Wechsler Intelligence Scale for Children, which has been standardized recently for use with children between the ages of 5 and 15 years. The new test is a downward extension of the Wechsler-Bellevue Scale for Adults.



262

A Picture Arrangement Test

This is not one of the Wechsler-Bellevue items, but it is similar to those in the picture arrangement section of that test. The subject is required to arrange the items into the proper sequence. The correct sequence for these pictures is given on p. 609. (Drawing by Alain, reproduced by permission. Copyright 1943 The New Yorker Magazine, *Inc.)*

language. Like some of the Stanford-Binet items at the lower age levels, these are known as *performance* tests. Picture arrangement (Figure 262) is one of the more difficult performance tests in this scale. In a sense it is a link between tests that are predominantly verbal and those that are predominantly motor, like certain performance tests considered later in this chapter.

HOW CONSTANT IS THE RELATIVE LEVEL OF TEST PERFORMANCE?

Before answering this question specifically with reference to I.Q., we might, with advantage, turn our attention to the consistency of brightness and dullness as evidenced in everyday life. In other words, does a child who is bright tend to remain bright and the child who is dull tend to remain dull, or do bright children ever become dull and dull children become bright? The answer is rather obviously that the bright tend to remain bright and the dull tend to remain dull. We might, with advantage, put this in another way. The child who shows a high initial level of achievement in relation to other children usually maintains a relatively high level of achievement. Likewise, the child who is initially below the average level of achievement usually remains below it.

We do not need intelligence tests to indicate that extreme cases of brightness and dullness tend to maintain their relative status. Such cases as the following illustrate later achievement that was foreshadowed by early accomplishment.

Childhood precocity

John Stuart Mill, the great English philosopher, logician, and economist, began the study of Greek at three, read Plato at seven, studied Latin, geometry, and algebra at eight, and at twelve was studying philosophy. At the age of six years he began a history of Rome.[10]

Charles Dickens, before the age of seven, was reading such books as *The Vicar of Wakefield, Don Quixote,* and *Robinson Crusoe.* He also wrote a tragedy before he was seven.[11]

At the age of eight, Goethe was preparing for the university. During his tenth year he wrote what are said to be "clever Latin essays." At sixteen he could not only read five languages in addition to German, he was reading the classics in them. He studied law, philosophy, and literature. At twenty-three he published his first important work. In adult life he excelled in the writing of literature, but he was also a scientist and statesman.[12] Similar feats could be cited for most of the three hundred geniuses of historical importance whose careers have been studied by psychologists.

Many of our great present-day scientists and writers also demonstrated their brightness at an early age. Others failed to exhibit any great childhood precocity. Even Einstein was no infant prodigy. At nine, according to a biographer, Albert was an "amiable dreamer," and everything he said was expressed only after careful consideration.[13] The genius of Einstein may at that time have been veiled by his reticence.

Terman's gifted children

In 1921 Professor Terman began a study of gifted children which is still in progress. Over one thousand children with I.Q.'s ranging from 130 to 200 were located. These have been interviewed at intervals over the years, the aim being to observe whether the promise of youth is being fulfilled. The latest report (1947), entitled *The Gifted Child Grows Up,* deals with the early adult life of these gifted individuals. There is no doubt that the early promise is being achieved for most.

At a mean age of thirty, the intelligence of the average member of this group was in the upper 2 per cent of the population. It was far above the average level for graduates of superior colleges and universities. Nearly 70 per cent of the group are college graduates. This group has more than eight times its proportionate share of positions in the professions. A large proportion of the men had distinguished war records. One became director of a great laboratory devoted to applications of atomic energy. Another headed a large project for the OSS. Still another was co-director, during the war, of a large-scale investigation of the physiological, bio-chemical and psychological effects of semi-starvation.

In 1944, 45 per cent of the gifted men had an earned income of $5000 and over as compared with 7 per cent for employed males of all ages in the United States. Over 13 per cent had earned incomes of $10,000 or more, despite the fact that they were in their early thirties.

The publications of Terman's gifted group are, to say the least, prodigious. These range from scientific articles and books to poetry, plays, essays and fiction. One, a professor in a medical school, published over 100 articles before he was thirty-five, and became executive head of his department. Another man has already written seven detective novels. Still another has written three novels, a book on inventions, and a scholarly book on witchcraft and magic. Many women of the group have become housewives and mothers, but some of these and others have also had professional careers. One is reported to be a talented actress as well as author of a successful Broadway play. Another is a concert pianist, a composer, and mother of three children. And so the story goes.[14]

Terman's group does include some failures, as one might expect. Quite a few did well through high school and then lost interest in college. One girl purposely "flunked out" so that she could do something more to her liking. Some did not get the chance to have a college education.

The average physical and mental health, character, personality and marriage adjustment of the gifted remain at or above the average of the general population. There is thus no ground for the commonly held view that brightness is offset by poor health and poor personal adjustment. Given a normal home and suitable educational opportunities, gifted children grow up to be the outstanding leaders of their day and generation. They are the most precious resources of any nation — not sideshow freaks, as the radio and newspapers sometimes would have us believe.

Consistent retardation

Each case of childhood precocity could be matched with one of continued retardation during childhood and on into adulthood. One case will suffice to illustrate the general picture presented by such mental retardation.[15]

> Donald Noname . . . was a young man of twenty in an institution for the feeble-minded, the Training School at Vineland, New Jersey. Here Donald was being educated along the lines in which he could most easily advance. He was a handsome chap with a pleasant face, an alert manner, and but little awkwardness. He was an excellent farm hand and especially apt in handling farm machinery. One of his teachers called him "the finest industrial worker in the school." He had learned to play the bass horn well in the school band. His education in public school had progressed to the level of the first grade but there he stuck for four years. After five years of good instruction at Vineland with more personal attention than he would ever have got in public school, he was still at the first-grade level. At the age of fifteen he did not do quite so well on intelligence tests as the average ten-year-old, and, curiously enough, in school work he was still back below the seven-year level. He could not put the words, *girl, river* and *ball* together into a single unitary sentence. He could not define words like *charity* or *justice*. Given money he could not make correct change. Conversation with Donald soon broke down the first impression of his intellectual competence. He had a poverty of ideas, a lack of originality, a very limited stock of general information, only a vague comprehension of abstract relationships. At the age of nineteen he wrote the following letter to Santa Claus:
>
> "My dear Santa I wish you would please send me thease things a pair of russet button schoes size 8 and either a blue or reed norfalk sweater and about a dozen gellet safte razer blades I well be glade to get thease things yours truly Dondal Noname to frend Sata Cluas."
>
> Donald is a moron. Today he is a competent chauffeur for a family that takes care of him, but expects nothing brilliant.

More extreme cases of mental retardation are illustrated in Figure 263. Children are "born that way" and very little if anything can be done to educate them. Many such defects result from an inadequacy of the prenatal environment (pp. 97–99). Some appear to be hereditary.

I.Q. constancy

If mental growth is constant, the Stanford-Binet I.Q. will, under certain conditions, remain constant. The test is constructed in such a way that this will be true, provided it is properly administered and scored, and the children tested have had opportunities comparable to those of the standardization group. Thus, if a child's level of performance on the test at six years is equivalent to that of average six-year-olds in the standardization group, his level of performance at seven years will be equivalent to that of the average seven-year-olds in the standardization group. If his mental growth is constant,

263

Some Clinical Types of Feeblemindedness

Left: microcephalic (after Wallin). Center: hydrocephalic (after Tredgold). Right: mongolian (after Tredgold).

in other words, his I.Q. will remain around 100 at each yearly level up to that at which mental growth, as measured by the test, ceases. Likewise, the child of six whose test performance is ahead or behind that of other six-year-olds will, if his mental growth is constant, be the same relative distance ahead or behind the performance of seven-year-olds, eight-year-olds, and so on. His I.Q. will be approximately the same number of points above or below 100 at all of these ages.

On the average, there is less than a five-point (plus or minus) change in the I.Q. from year to year after about the fifth or sixth year. Children whose I.Q. is 100 at six will probably not have an I.Q. of less than 95 or more than 105 at seven, eight, nine, and so on. We have said "probably" because there are certain exceptions to the rule.[16]

Changes in the I.Q.

Two cases exhibiting a progressive change in I.Q. have recently been reported.[17] One child, whose initial Stanford-Binet I.Q. was 123 (C.A. five years, six months) had an I.Q. two years later of 126. The I.Q. then changed at yearly intervals as follows: 133, 150, 143, 147, 151. The child's school progress also showed a spurt. Another child, first tested at the age of six years, had an initial I.Q. of 94. One and one half years later her I.Q. was 100. However, annual tests over the next three years yielded successively smaller I.Q.'s. These were 89, 80, and 74. The child's school record also exhibited a decline. In neither of these cases was there any evidence of changes in health, in schooling, or in the home environment which might have accounted for the change in I.Q.

Adverse physical conditions may affect the I.Q. Sometimes removal of an adverse physical condition, like deficient thyroid function, is followed by a change in the I.Q.[18]

Consider the case of an allegedly feebleminded boy, who, at the age of twelve, had a mental age comparable to that of a child of eight. The boy's intelligence quotient (I.Q.) — the ratio of his performance to the average for his actual age — was 67, as compared with the norm of 100. When he took an intelligence test

for the first time, he was stunted in physical growth and had been leading a very quiet life at home, where there had been no systematic attempt, for several years, to stimulate his mental development. He was then taken to an expert diagnostician who made practically all the tests of metabolism known at that time to medical science. The boy was prescribed a special diet, given thyroid treatment, and at the same time placed in the hands of a trained teacher. Within two years he had grown considerably more than could have been expected without medical treatment and the soundness of his physical condition had vastly improved. He was tested again, this time at the age of fourteen, when his mental age was twelve, and his intelligence quotient was 86. How much of his improvement was ascribable to medical treatment is uncertain, but the boy was able to meet new problem situations which he had never solved before, demonstrating that his mental development was not the consequence of mechanical drill.

A possible interpretation of this case is that the thyroid defect, perhaps through the lethargy that goes with it, prevented the child from learning as much as children of his age, but of normal health, are able to learn. When his defect was corrected, his motivation became better. With a teacher provided to guide his learning, he was able to come closer to the performance norms for children having normal health and opportunities to learn.

Unusual environmental conditions lead to changes in I.Q. The average Stanford-Binet I.Q. of children, like the Kentucky mountaineers, who are isolated from normal educational opportunities, is below the average for children given normal schooling.[19] The I.Q. of these children usually declines with age. This decline probably occurs because a poor environment does not handicap so much on the simpler tests at the lower age levels as it does on the more complex tests at the upper age levels, where language plays a bigger part in the test. When given normal educational opportunities, these children, despite their initial handicap, often show a marked increase in I.Q.

Certain racial groups, like the Indian and the Negro, are often handicapped educationally. The average I.Q.'s of Indian children range between 70 and 80. The I.Q. of northern Negroes has ranged, in the various groups studied, from around 80 to 90. Groups of southern Negroes, on the other hand, usually have average I.Q.'s between 75 and 80.[20] One of the very few individuals with an I.Q. of 200, however, is a Negro child. Her father is an electrical engineer (Case School of Applied Science and Cornell University) and her mother a normal-school graduate and a former school-teacher. This child, by contrast with most Negro children, has had an excellent home environment and has attended a good city school for both Negroes and whites. She is a full-blooded Negress.[21] Chinese and Japanese children tested in California have average I.Q.'s of around 100. These, however, are highly selected groups with good home environment and good schooling.

Some of the differences in I.Q.'s between the above groups and more privileged groups may be attributed to differences in educational opportunity. The fact remains, however, that the Stanford-Binet Test was standardized on white children in schools rated in their community as average. Since children living in relative isolation do not have average schooling, and since the Negro and the Indian also frequently suffer educational handicaps, the Stanford-Binet Test is not applicable to them. In fact, an I.Q. derived from this test would, for them, be practically meaningless.

After they attend nursery school a year or two, children often show an increase in I.Q. Several studies have shown no increase, but several others have shown an average increase of seven points after one year, and of ten points after two years of nursery-school attendance.[22] These studies have been criticized from almost every conceivable angle,

including the point that I.Q.'s determined for preschool children change under any circumstances.[23] The crucial fact, however, is that nursery-school children (depending somewhat on the particular nursery school attended) have educational opportunities not enjoyed by children on whom the Stanford-Binet Test was standardized. This applies, also, to other tests not standardized with adequate representation of nursery-school children. The advantage which nursery-school children (as a group) have over the standardization group may well be reflected in a rise of seven to ten points in the I.Q., at least during the preschool and early school years.

What basis is there for the rise in points? A child who has been in a nursery school a year usually has learned to co-operate with adults other than his parents much more than before he went to nursery school, and much more than another child who has not gone to nursery school. He is often given tests of one kind or another, especially if connected with a university nursery school, which may get him accustomed to test situations. He is sometimes used by graduate students as a subject in their experiments, which may also add to his preparation for taking the Stanford-Binet, or a comparable test. In many nursery schools, if not all, the child builds with blocks, threads beads, listens to stories being read, puts simple jigsaw puzzles together, and, among many other things, learns to dress himself. Many of these activities are directly or indirectly involved in the test at the early age levels. The preschool children in the standardization did not, as a group, have such opportunities to learn things which would be helpful in the testing situation.

In short, regardless of whatever other criticisms are made of the nursery-school studies, an I.Q. determined for nursery-school children does not mean the same thing as an I.Q. determined for the same child before he went to nursery school, or for other children of the same age who have not gone to nursery school. The Stanford-Binet I.Q., as we have already said, is meaningful only when used with children who have had approximately average educational opportunities for their age level.

Although the I.Q. fluctuates markedly in cases like those cited, the general picture is one of relative constancy. Granting continuance of average educational opportunities in the school system and in the home, and reasonably good health, the child with an I.Q. of 100 will probably maintain average status, the child with a higher than average I.Q. will probably maintain higher than average status, and the child with a below average I.Q. will probably maintain below average status. These children will probably have the same I.Q., within a range of about five points in either direction, between the years of, say, six and twelve. Below six and above twelve, the Stanford-Binet Test is not so good a differentiating instrument as between the year levels indicated, and fluctuations of I.Q. above and below these levels may be attributed to this fact rather than to actual changes in relative status.

But the student may well ask, "Does the I.Q., which has so far been dealt with only as an index of relative performance, really indicate how much intelligence a person has?" The answer to this question is that the concept of intelligence is a relative concept. Intelligence is a function which, as was pointed out earlier, we infer from individual differences in performance. The test does not measure intelligence in any absolute sense — it measures relative performance. But the student may say, "I recognize that intelligence cannot be measured directly as one measures a person's height or weight, but how about the differences in I.Q. — do they not indicate a difference in intelligence, a difference in this versatility function?" The answer is that, under conditions which make the Stanford-Binet Test applicable, differences in I.Q. do represent differences in in-

telligence. All children with I.Q.'s of 100, who have had average opportunities to learn and whose health is not seriously defective, may be said to have approximately the same intelligence, or the same versatility in the use of symbolic processes. Likewise, all children who, under comparable conditions, have an I.Q. of 120, may be said to be more intelligent or versatile symbolically than all children who, under comparable conditions, have an I.Q. of 100. We may say, too, that all these children are equally in advance of the average level of intelligence. We do this without measuring what some have called raw intelligence.

HEREDITY AND ENVIRONMENT AGAIN

Closely tied in with the question of what the Stanford-Binet Test measures and the constancy of the I.Q. is the question of whether differences in I.Q. represent, or reflect, differences in heredity or in environment. This is an issue on which there has been more heated controversy than on any other issue in psychology.

We have defined human intelligence as versatility of adjustment, especially in the realm of symbolic processes. We have said that its growth is a function of maturation (primarily an hereditary influence) and of what has happened to the individual, or what he has learned (primarily an environmental influence). Defined in these terms, intelligence is obviously attributable to both heredity and environment.

But how about differences in intelligence? It is obvious that differences in intelligence would also result from heredity, from environment, or from both. Differences in I.Q. — in relative versatility — may reflect an hereditary or an environmental influence, or a combination of these influences.

When heredity is constant, as in identical twins (pp. 94, 110), any difference in I.Q., assuming that the conditions of the standardization group have been met, represents a difference in environment and in environment alone. If we could hold the environment constant (which we cannot do in any strict sense), average differences in I.Q. greater than plus or minus five points would represent average differences in heredity and in heredity alone.

One will recall, from the discussion in Chapter 5, that rats reared in the same environment differ greatly in maze performance, and that the difference is attributed to a difference in their inheritance. There is no doubt in the writer's mind that, were we able to hold the environment of human beings constant, there would be marked differences in intelligence which we would be justified in attributing to differences in inheritance. The closest we can come to the requirement of a constant environment in human beings is to give them comparable opportunities to learn the kinds of things involved in the Stanford-Binet Test. We can then assume that, within certain limits which cannot completely be specified, the differences in I.Q. among these individuals would represent a difference in their inheritance.

The reason for not being dogmatic about this statement is that we cannot even be certain that individuals in the same school and home always have comparable opportunities to learn. They may differ in health. The teacher may treat one child kindly and the other harshly. The parents may take different attitudes, helping one child with his studies and not helping the other. How much difference in the I.Q. these variations in health, in school, and in the home would produce is not known. That they would produce some effect is almost certain.

Those who define intelligence as an innate capacity and regard the I.Q. as an index of this capacity might not agree with the above conclusions, so it is well to see how their point of view could, in a sense, be reconciled with that expressed here. Let us, first of all, consider two definitions of intelligence which invoke the concept of inherited ca-

pacity. One writer defines intelligence as "An inherited capacity of the individual which is manifested through his ability to adapt to and reconstruct the factors of his environment in accordance with the most fundamental needs of himself and his group."[24] Warren's *Dictionary of Psychology* gives, among other definitions, the following: Intelligence is "the capacity of certain organisms to meet a novel situation by improvising a novel adaptive response."[25] Both definitions suggest that versatility, especially with respect to symbolic processes, is an aspect of intelligence, but intelligence is defined as the capacity for such versatility. The first definition says that intelligence is an innate capacity, while the other does not. But the dictionary from which the latter was taken defines capacity as innate. It says that capacity is "the full potentiality of an individual for any function, as limited by his *native constitution* and as measured, theoretically, by the extent to which that function would develop under optimal conditions."[26]

If intelligence is an innate capacity, then it cannot be affected by environment, and, if the I.Q. is a measure of innate capacity, which is, of course, determined at fertilization, it cannot fluctuate. We avoid this obviously ridiculous predicament if we define intelligence in terms of what we actually measure, or sample, by use of the intelligence tests — namely, versatility. Some who have said that "intelligence is what the intelligence tests measure" have just this predicament in mind.

"But," the student may ask, "don't those who define intelligence as an innate capacity have any basis for this definition?" The answer is that they do have a basis, but a somewhat precarious one. They reason somewhat as follows: with educational opportunities approximately constant, as in standardization of the Stanford-Binet Test, I.Q.'s do differ widely from one child to another. With the assumption that educational opportunities (environmental factors) are constant, there follows the conclusion that what underlies a given I.Q. is inherited, or that the differences in I.Q.'s reflect inherited differences in capacity. They then define intelligence as an innate capacity.

One avoids much confusion, however, if he speaks of intelligence as versatility, which is measurable, or possible of sampling, by use of tests, rather than as a capacity, which is not measurable directly.

One may then ask, "Are differences in versatility (or in I.Q. which is said to be an index of it) the result of differences in capacity to *develop* intelligence?" We would answer in the affirmative, but specifying, of course, that the standardized conditions of the test be met, and that it be recognized that some fluctuation in I.Q. may occur as a result of inability to hold educational opportunities exactly constant.

One may then ask, "Is the capacity to develop intelligence due to heredity or environment, or both?" We would unhesitatingly answer, "Both."

"But," the student may ask, "which produces larger differences in this capacity to develop intelligence — heredity or environment?" We would answer this question, as we did in Chapter 5, by saying that larger differences in intelligence — or capacity to develop it — can be produced by variations in heredity than by variations in environment.

There are no experimental data on human beings to support this view — because we cannot hold environment strictly constant for them — but the results of animal experiments and inferences which may be drawn from the evolution of intelligent behavior unqualifiedly support it. An old saying, which is quite to the point, is that "you can't make silk purses out of sows' ears." What you have to begin with (heredity) always places very large limitations on what you can develop from it by means at your disposal (environment). A rat in a human

environment responds only to the grosser aspects of it. A monkey is more responsive than a rat to what a human being's environment has to offer. A chimpanzee is still more responsive. But the most favorable human environment could never make a genius out of a chimpanzee any more than out of a monkey or a rat. The differences in intelligence from one of these levels to another are obviously ascribable to the inherited makeup of the organisms involved.

Likewise, a congenital idiot, whose idiocy results from defective inheritance or defective prenatal environment or both (pp. 98–99), will also make relatively little of the opportunities for development offered by a human environment — even the finest that one might provide. His mental growth may be no more influenced by the educational opportunities available than would be that of a chimpanzee. On the other hand, a child with superior endowment may make the fullest use of the opportunities provided by his environment. He may even get out of a nonstimulating educational environment, whereas the idiot could not if he wanted to.

We say that the initially superior individual *may* make the fullest use of his opportunities because there are many instances, especially at the upper school ages and in college, where those of superior endowment do not make the best possible use of their opportunities. Those of low initial ability could not, even if they would, respond to these opportunities. Those of high ability, on the other hand, can make use of these opportunities if they are so inclined.

THE VALUE OF DETERMINING A CHILD'S I.Q.

We have seen that, provided a child has had average or normal opportunities to learn, his I.Q. gives us an approximate index of his level of achievement. Of what use is such information? Three uses are of outstanding importance:

(1) If the child's I.Q. is lower than that of the least successful children in the school system, we can keep him from going through the regular educational channels, where he will fall farther and farther behind his schoolmates. Many school systems provide so-called "opportunity classes" where special attention is given the mentally backward child. He can go farther this way than in the regular classes — without being made to feel inferior and without detracting from the attention other children should receive from the teacher. Moreover, there can be an increasing emphasis, as the child gets older, on practical things that he can learn to do instead of increasing emphasis on symbolic activities that are beyond him.

Those children who are too low mentally to profit from any regular schooling can be put in institutions where, with others of their kind, they can be reasonably well adjusted. One will recall, from what was said earlier, that the tests were first devised for this purpose.

Some of the higher-grade feebleminded make useful citizens if properly trained. Most institutions for the feebleminded train the higher-grade inmates to do useful work around the institution and, in some instances, to do housework in homes where they are placed and supervised.

(2) Children with exceptionally high intelligence are often a problem to their parents, to their teachers, and to their other associates, unless sorted out and given opportunities to use their abilities. Teachers without special training are not always good at recognizing superior intelligence. Here is a case in point. The Negro girl of 200 I.Q. mentioned earlier in this chapter was rated lower in intelligence by her teacher than a child whose I.Q. turned out to be 100. Inability of the teacher to recognize genius in her pupils sometimes leads her to report as "trouble-making" what, for the gifted child far more advanced than she is in intelligence, is only natural. Consider the following statement by the late Leta Hollingworth,

a genius who became a psychologist especially interested in the education of mentally gifted children.[27]

As a form of failure to suffer fools gladly, negativism may develop. The foolish teacher who hates to be corrected by a child is unsuited to these children. Too many children of I.Q. 170 are being taught by teachers of I.Q. 120. Into this important matter of the selection of the teacher we cannot enter, except to illustrate the difficulty from recent conversation with a ten-year-old boy of I.Q. 165. This boy was referred to us as a school problem: "Not interested in the school work. Very impudent. A liar." The following is a fragment of conversation with this boy:

What seems to be your main problem in school?

Several of them.

Name one.

Well, I will name the teachers. Oh, boy! It is bad enough when the pupils make mistakes, but when the teachers make mistakes, oh, boy!

Mention a few mistakes the teachers made.

For instance, I was sitting in 5A and the teacher was teaching 5B. She was telling those children that the Germans discovered printing, that Gutenberg was the first discoverer of it, mind you. After a few minutes I couldn't stand it. I am not supposed to recite in that class, you see, but I got up. I said, "No; the Chinese invented, not discovered printing, before the time of Gutenberg — while the Germans were still barbarians."

Then the teacher said, "Sit down. You are entirely too fresh." Later on, she gave me a raking-over before the whole class. Oh, boy! What teaching!

It seemed to me that one should begin at once in this case about suffering fools gladly. So I said, "Ned, that teacher is foolish, but one of the very first things to learn in the world is to suffer fools gladly." The child was so filled with resentment that he heard only the word "suffer."

"Yes, that's it. That's what I say! Make 'em suffer. Roll a rock on 'em."

Before we finished the conversation, Ned was straightened out on the subject of who was to do the suffering. He agreed to do it himself.

I will cite another conversation, this time with a nine-year-old, of I.Q. 183.

What seems to be your main trouble at your school?

The teacher can't pronounce.

Can't pronounce what?

Oh, lots of things. The teacher said "Magdalen College" — at Oxford, you know. I said, "In England they call it Modlin College." The teacher wrote a note home to say I am rude and disorderly. She does not like me.

Just one more conversation, this time with an eight-year-old, of I.Q. 178, sent as a school problem:

What is your main trouble at school?

My really main problem is not at school.

Where is it, then?

It is the librarian.

How is that?

Well, for instance, I go to the library to look for my books on mechanics. I am making a new way for engines to go into reverse gear. The librarian says, "Here, where are you going? You belong in the juvenile department." So I have to go where the children are all supposed to go. But I don't stay there long, because they don't have any real books there. Say, do you think you could get me a card to the other department?

One can readily see that children like this might get into many difficulties, perhaps drift into delinquency, unless treated by parents, teachers, and others with due regard to their intelligence.

There are now special schools in some cities where children with very high I.Q.'s learn the three R's in about one quarter of the time required in regular schools and spend the rest of their time on projects which whet their almost insatiable curiosity.

At the Speyer School in New York City there is a class for "rapid learners" established by Mrs. Hollingworth. Seven- to nine-year-olds in this class work together under teacher guidance. At the time when Mrs. Hollingworth last wrote, they were, among other things, preparing a series of handbooks entitled "The Evolution of Common Things"; they had cards to the New York Public Library and did their research there under teacher guidance; they worked

on a project dealing with biography in which they "biografied" (a term of their own invention) one hundred people; they studied French language and literature; they took trips to places of educational interest; they studied nutrition; played games involving intellectual skill (chess and checkers); they studied handicrafts; and they studied a number of other things. No home work was assigned.

Mrs. Hollingworth looks upon such children as possible benefactors of the human race who might, without such opportunities, become clever rogues and thieves — aggressively set against the society that, in the shape of their teachers, frustrated them unduly. Think of the child who wanted to make the teacher suffer.

Mrs. Hollingworth says that

> The intellectual interest and capacity of young children who test from 160 to 200 I.Q. is incredible to those who have had no experience with the teaching of such children. We have in our classes about a dozen of such extreme deviates. They are the truly original thinkers and doers of their generation. A book could be made of the incidents constantly occurring which denote the qualities of their minds. It is these children who suffer most from ennui in the ordinary situation.
>
> For instance, recently in the discussion of the biography of Madame Curie, the question was raised by a pupil as to what "radium really is." One suggested that "radium is a stone." Another said that "radium is a metal." The person in charge of the class then said, "What is the difference between a stone and a metal?" A pupil of an extremely high degree of intelligence rose and said, "The main difference is that a metal is malleable and ductile, and a stone is not." He then enlarged very precisely upon "what these properties are." At the moment of this discussion, this boy was nine years six months old. The others listened attentively and understood the elucidation.[28]

Follow-up studies have demonstrated that mentally superior children who receive the intelligent treatment they deserve from parents, teachers, and others usually make superior citizens. The child's brightness is actually a handicap to him, however, if it leads him into conflict with his parents and teachers. Because of his brightness, the superior child can exert a powerful influence in society either for good or ill.

(3) The writer has seen many a student unhappy and maladjusted in college because his parents set a level of aspiration for him, or encouraged him to develop one, which was far above his level of accomplishment. There are boys, for example, whose I.Q.'s are far below the minimum requirement for successful college work, yet who have their hearts set on becoming physicians. One girl of the writer's acquaintance whose parents wanted her to have a college education was so unhappy because she could not make the minimum grades required for graduation, and to get into a sorority, that she committed suicide, leaving a note saying that she was unable to do the things which people expected of her. Much of this grief would be prevented if parents would find out the level of a child's intelligence before encouraging him to develop levels of aspiration beyond the possibility of accomplishment. Many boys and girls who go to college would do better, for their own happiness and the good of society, if they went to a trade or business school instead.

Intelligence tests offer help to parents and others in the vocational guidance of youth. They are recognized quite generally among psychologists as tests of aptitude for successful school performance. Such performance is, of course, a prerequisite for the professions. Vocational aptitude tests of a more specialized nature are also helpful, but these are considered in the following chapter.

PERFORMANCE TESTS OF INTELLIGENCE

Strictly speaking, all tests of intelligence are measures of performance. However, the term *performance* is customarily applied to

tests which call for a minimal understanding and use of language. These tests provide a measure of fundamental psychological processes, such as reasoning and seeing relationships, without at the same time depending upon particular cultural or educational opportunities. They enable us to measure the intelligence of individuals: (1) who are too young to have learned a language; (2) who are illiterate through lack of educational opportunity or feeblemindedness; and (3) who speak only a foreign tongue. They have been used in numerous places where tests of the Stanford-Binet variety would be useless. Since performance tests do not require use of the English language or of anything peculiar to our culture, some of them have been used to compare the intelligence of Australian aboriginals and African bushmen,[29] to compare the intelligence of different European groups,[30] to compare the intelligence of isolated mountaineer children with that of children given normal educational opportunities,[31] and to compare the intelligence of Negroes and whites.[32] The simplest performance tests are of course those used with infants.

Performance tests covering the period from early childhood to maturity

Several performance tests have been devised for use with individuals between early childhood and maturity. Such tests have usually been standardized along lines already described for the Stanford-Binet Test. Most of them provide norms based upon average performance at yearly age levels. Thus, M.A. and I.Q. may be derived. Sometimes, as in the Stanford-Binet Test, there

264

The Seguin Form Board

The child is timed while he places the blocks in the proper holes. An average child of 33 months requires 222 seconds. At 69 months, the average time required is 35 seconds.

265

The Merrill-Palmer Block Building Test

Here a child of 4 years is seen building a structure like that made by the examiner. (From Goodenough, F. L., and Maurer, K. M., The Mental Growth of Children from Two to Fourteen Years. *Minneapolis: Univ. Minnesota Press, 1942.)*

are different items at the various age levels. In other instances the same items are used at a number of age levels, but with different time and error norms for each level.

One of the best known of the performance tests for children approaching the school age is the Merrill-Palmer Scale. It includes such items as the Seguin Form Board (Figure 264) and the Block Building Test (Figure 265).

One well-known performance test merely requires the child to draw a man.[33] He is instructed, "Make a picture of a man. Make the best picture that you can." Scoring is in terms of how many important parts of the man, such as eyes, fingers, nose, mouth, and so on, are included in the drawing. No importance is attached to artistic qualities. Age norms are available for four thousand children. The range covered by the scale is from three to thirteen years. Norms are in terms of the average number of points, out of a possible 51, at each level. M.A. and I.Q. are derived by use of these norms.

Another interesting performance test is that of Porteus, which utilizes a series of mazes used at age levels from three to fourteen years.[34] There is one maze at each level except thirteen. The subject is instructed to trace with a pencil the correct pathway (see Figure 79) from entrance to exit. When his pencil crosses a closed path, he is given a new copy of the maze and must start again from the beginning. If an error is made on this second trial, the child is regarded as having failed the test at that age level. (At the twelve- and fourteen-year levels, four instead of two trials are given.) As in the Stanford-Binet scale, a child is allowed to proceed until he fails the test at a particular

age level. His score is then derived in a manner which we shall not take space to describe here. M.A.'s and I.Q.'s are calculated for performance on this test. Porteus believes that the maze test gives a measure of processes such as power of sustained attention, foresight, and prudence, aspects of intelligence which, he claims, are not measured by the Stanford-Binet Test. He regards his test as supplementary to, rather than a substitute for, the Stanford-Binet. Porteus has shown its usefulness in situations where the Stanford-Binet would be useless; namely, in the measurement of primitive intelligence. Recent studies have shown that patients tested before and after psychosurgery (pp. 69–70) do not show much decline in Stanford-Binet performance, but a large decline in Porteus maze performance — apparently because of a decrease in "prudence and forethought and ability to profit by experience." [35]

266 **The Kohs Block Design Test as Used in the Wechsler-Bellevue Scale**

The subject is required to arrange the blocks to match the sample pattern.

The Wechsler-Bellevue Scale, some items of which were mentioned earlier, includes several performance tests. One of these, the Picture Arrangement Test, has already been illustrated (p. 518). Figure 266 shows a subject doing the most difficult of the Kohs Block Design Tests, also in the Wechsler-Bellevue Scale. The subject is given sixteen varicolored blocks and a card which indicates the design to be arranged. He is timed while he arranges designs of increasing complexity. Credits increase with a decrease in the time required to arrange a pattern.

GROUP TESTS

Value of group tests

Administration of individual tests, both verbal and performance, is usually laborious and time-consuming. Administration of the Stanford-Binet Test requires a highly trained tester to spend an hour or more with each individual. Whenever it is necessary to obtain a quick estimate of intelligence in large numbers of individuals, as was the case in 1917–18, when 1,750,000 draftees were tested, and in 1941–45, when over 10,000,000 selectees were tested, the testers used a simpler and more rapid method than that provided by individual tests.

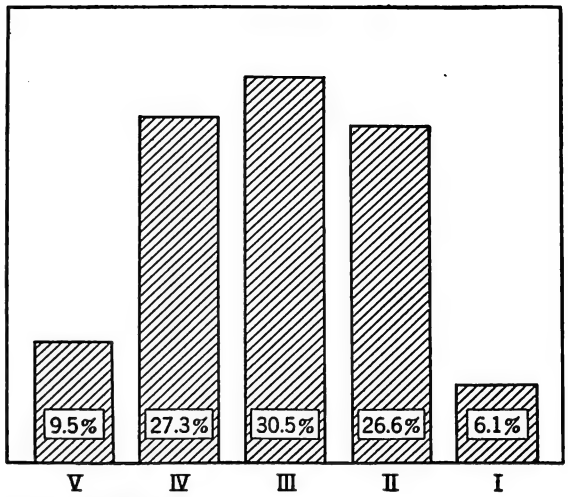
Prior to 1917, psychologists had begun to devise group tests of intelligence, but such tests had not been published. When psychologists were asked to investigate the intelligence of draftees, they formed a committee which considered all earlier intelligence tests and finally developed two, a verbal and a non-verbal, which could very quickly be administered to large groups, and just as readily scored. These were known, respectively, as the *Army Alpha* and *Army Beta* tests. Principles underlying selection of items for the tests were similar to those fol-

lowed in the development of the Stanford-Binet Test. In other words, the items were such as to measure those psychological processes which are regarded as important aspects of intelligence, the tests were intrinsically interesting, and their performance did not require special schooling. Administration and scoring of the tests was quickly mastered, hence a long period of training and practical experience such as that required for administration and scoring of tests like the Stanford-Binet was not required. During the recent war, as a matter of fact, tests were machine scored. The test blank, marked with a special electrolytic pencil, was inserted in a machine, and the score was read from a dial.

Administration of these tests to draftees enabled psychologists to select the feeble-minded (of which there were several thousand); those who, due to defective intelligence, should be given relatively simple tasks to perform; those whose intelligence indicated that they might be good officer material; and those whose intelligence fitted them for other types of work.[36] The distribution of grades on the Army General Classification Test (AGCT) for all men inducted up through June of 1944 is shown in Figure 267. We shall again make reference to these data in the next chapter, which discusses aptitudes.

The value of group intelligence tests became so apparent, as a result of the army experience, that many other group tests, designed for school and college use, soon appeared.

The chief disadvantage of group tests as compared with individual tests is that those who administer the group tests cannot be sure that each individual is at his ease, that he is in a fit condition to be taking the test on that particular day, or that he is co-operating to the best of his ability. In situations where large groups are to be tested in a hurry, these shortcomings must be overlooked.



267

Distribution of Grades on the AGCT

Those in Grade I made standard scores of 130 or over; Grade II, 110–129; Grade III, 90–109; Grade IV, 70–89; and Grade V, under 70. (After Boring, E. G. (Editor), Psychology for the Armed Services. *Washington: Infantry Journal Press, 1945, p. 241.)*

When group intelligence tests are used in school and college, they serve two main purposes. In the first place, they may be used to select those who will be admitted The correlation of around .60 between scores on such tests and college marks suggests their predictive value. In the second place, they may be used for guidance purposes. Most students take such a test when they enter college, and their scores are filed away in the registrar's office or the office of the dean. If a student made a very low score on the test, he may have been asked to take an individual test, perhaps the Wechsler-Bellevue, as a check on his group test performance. In any event, if he gets into scholastic difficulties, and a record of test performance is available, it may be used in counseling him concerning his special difficulties. If the record shows low intelligence, he may be asked to leave school or to change his course to one more in keeping with his spe-

cific aptitudes. If the record shows a high score on the intelligence test, however, the personnel assistant to the registrar or dean may investigate his motives for being in college, his study habits, or perhaps consult with him concerning personal problems which might interfere with his school work. The investigator may even give him some personality tests of the kind to be discussed in the final chapter of this book.

Typical group tests illustrated

Although group tests measure psychological functions similar to those measured by individual tests, they usually include a large number of items pertaining to each psychological process. These items are arranged in such a way as to objectify answering and scoring. The items are, for example, true-false questions, completion exercises, and matching problems. They are answered by underlining a word or a number, by putting a cross in a square, by drawing in the missing parts, or by writing a number. Scoring is then accomplished either by placing a key with the correct answers against the answers of the person tested and checking off the discrepancies, or by using a scoring machine.

The following is a selection of items from verbal and nonverbal group tests.[37]

Illustrative Items from Group Tests of the Verbal Variety

Make a cross in the square which represents two times the sum of two plus three less one half the square of four —

☐1 ☐2 ☐3 ☐4 ☐5

15 16 14 17 13 18 .... Which two numbers should come next? (1) 12 and 19? (2) 13 and 20? (3) 14 and 20? (4) 19 and 20? (5) 12 and 5? Put a cross in the appropriate square —

☐1 ☐2 ☐3 ☐4 ☐5

If 5½ tons of bark cost $33, what will 3½ tons cost? (   ).

A train is harder to stop than an automobile because
☐ it is longer ☐ it is heavier ☐ the brakes are not so good.

If the two words of a pair mean the same or nearly the same thing, draw a line under SAME. If they mean the opposite or nearly the opposite, draw a line under OPPOSITE.

comprehensive-restricted	same	opposite
allure-attract	same	opposite
latent-hidden	same	opposite
deride-ridicule	same	opposite

If, when you have arranged the following words to make a sentence, the sentence is true, underline true; if it is false, underline false.

people enemies arrogant many make	true	false
never who heedless those stumble are	true	false
never man the show the deeds	true	false

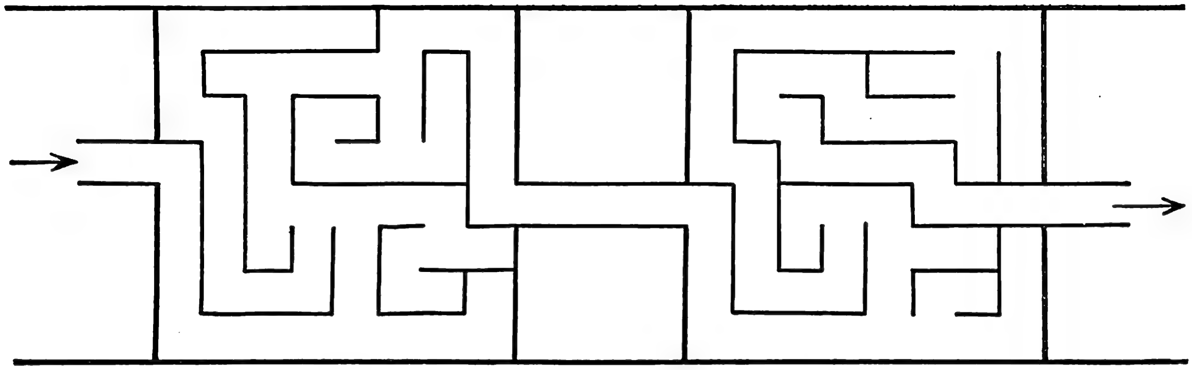
The pitcher has an important place in — tennis football baseball handball Underline which

Dismal is to dark as cheerful is to — laugh bright house gloomy Underline which

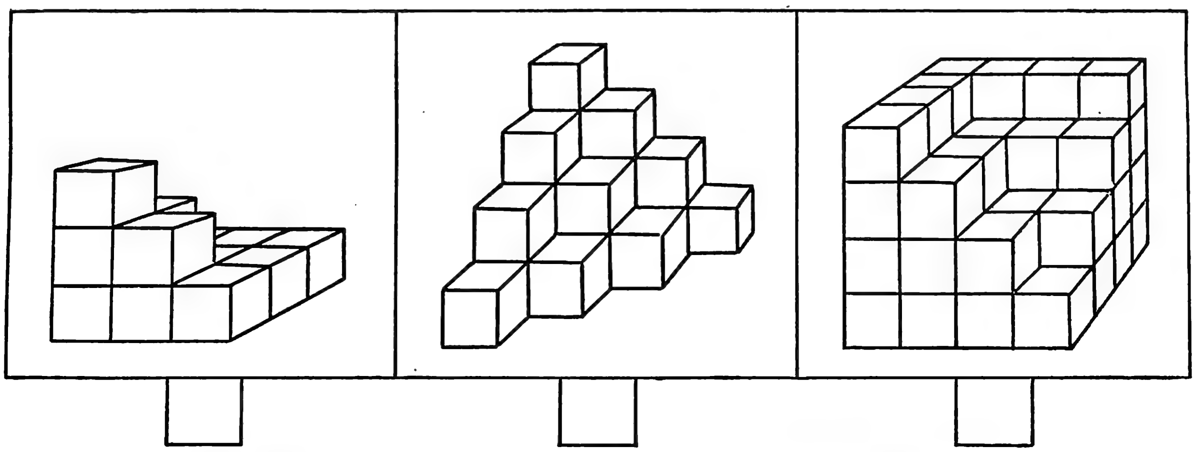
Truth is to gentleman as lie is to — rascal live give falsehood Underline which.

Illustrative Items from Group Performance Tests

Instructions for these are given by the examiner and procedure is demonstrated on a blackboard. The question below each item will serve to indicate to the reader what procedure is to be followed.



Which is the shortest path through the maze?



How many cubes in each pile? Write number in appropriate square.

X	X	X	X	O	O	O	X	X	O	X	X	X	X	O	O	O	X	X	O										

Complete the series.

1	2	3	4	5	6	7	8	9
—	И	⊐	L	U	O	Λ	X	=

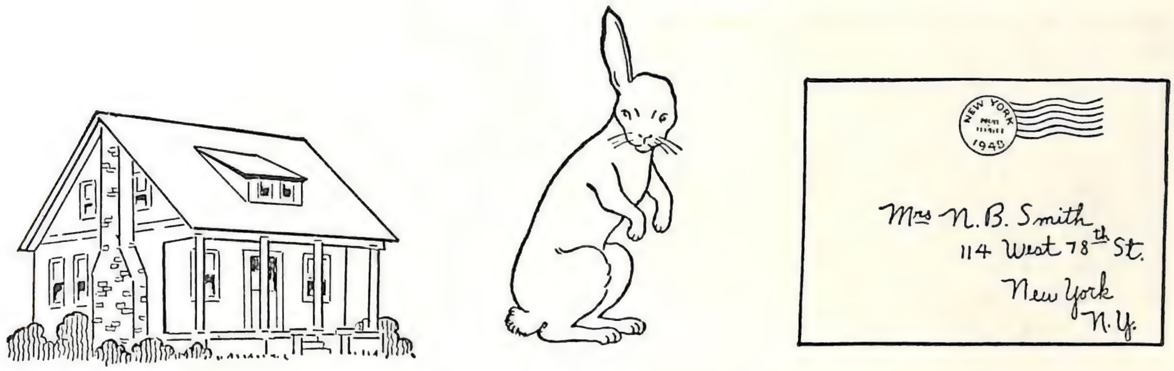
9	3	8	6	4	1	5	7	2	6	2	4	8	1	3

Substitute the correct symbols in the bottom row

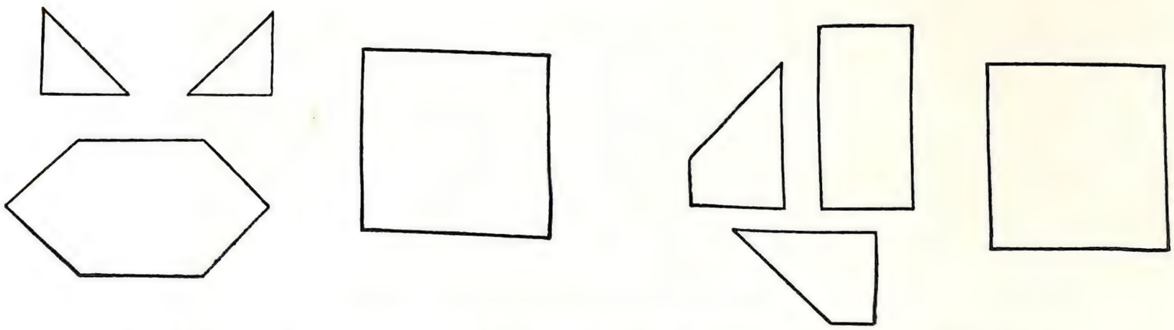
6543920817. . .6543920871

7611348879. . .78111345879

Indicate whether the last number is the same as the first.



Indicate the missing parts.



Make lines in the square to indicate the position taken by the parts fitted into it.

Interpretation of scores from group tests

Group tests are customarily scored in terms of the number of items correct. A particular score is then compared with norms determined for a large group of individuals. In many instances the score of an individual is interpreted in terms of what per cent of other individuals make scores above (or below) his score. If only 20 per cent of the large group on which the test was standardized exceeds an individual's score, we say that he has a percentile rank of 80. A score at the 98th percentile, to give a further illustration, would be one which only 2 per cent of the group betters and one which 98 per cent fails to reach. It is seldom that M.A.'s or I.Q.'s are derived for group tests. When they are derived, the procedure is an indirect one.

Many group tests taken in high school and college are not intelligence tests, but *achievement* tests in algebra, trigonometry, or other specific subjects. There are also high-school achievement tests which provide an index of what one has learned in a variety of subjects taught at the high-school level. These tests are standardized, administered, and scored along lines similar to group intelligence tests. The level of performance on these tests is often highly correlated with intelligence-test performance, but the tests measure special knowledge which only those who have had the courses in question could be expected to know. It is obvious, therefore, that a highly intelligent student might fail a test on achievement in algebra, American history, French, or some other high-school or college subject.

Aptitude tests are also to be distinguished from intelligence tests, which are themselves often considered to be tests of general aptitude for school work. Some are even called "scholastic aptitude tests." The distinction

between such general aptitude tests and tests of special aptitude will be clear after you have read the following chapter. Examples of these special aptitude tests are found in such fields as music, graphic art, and mechanics. A student might do miserably on one of these special tests, yet rate as a genius on a general intelligence or "scholastic aptitude" test.

The so-called "Intelligence Tests" and "I.Q. Tests" which appear in popular books, in the press, on the screen, and on the radio should not be confused with the intelligence tests of which we are speaking. The chief difference is that the popular tests are not standardized. Since they have not been tried out on large representative groups, no norms are available. The writer was once traveling in a Pullman with two well-known writers of popular psychological material. They were working on a book the title of which was something like "Testing your I.Q." Each would think up trick questions. They would then try them on each other. If both thought a question good, it was included. That was the only criterion for inclusion. These trick questions do not come within the range of everyone's experience. Items involved in scientific tests of intelligence are those which every person in the population on which the tests are used has had an opportunity to learn. They measure, not information as such, but ability to acquire and use information that is readily available to all who are tested.

GROWTH OF INTELLIGENCE

As the child grows older, his intelligence, like the innate and modified structures of which it is a function, undergoes a gradual increase. There is, in other words, an improvement with age in the child's versatility of adjustment — that is, in the readiness with which he gathers information and acquires new skills which enable him to adjust to the changing circumstances of his environment.

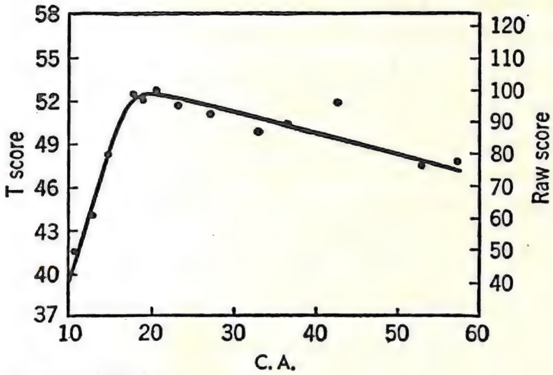
The rate of such growth in childhood is, as we have already seen, approximately constant under normal conditions. Mental age does not, however, increase without limit. The increments in M.A. with yearly increases in C.A. begin to decline in the early teens. This fact has already been mentioned (p. 516) in connection with determination of the I.Q. Stanford-Binet M.A.'s begin to show smaller increments beginning at around thirteen years. After the age of fifteen years, the average Stanford-Binet M.A. does not increase with increases in C.A.

The upper limit achieved by groups of different I.Q. differs significantly. Whereas normal individuals (I.Q. 90 to 110) reach the upper level at about fifteen years, the superior (I.Q. 110 to 120) reach it around eighteen, and the inferior (I.Q. 70 to 90) reach it at fourteen or earlier. After the upper level is reached, M.A. remains approximately constant for a period of some ten to twenty years. It then shows a decline.

What we have said so far concerns the results obtained with Stanford-Binet tests. Similar results are found with other tests. The age at which scores cease to show an increment, however, differs somewhat from one test to another. Different tests have yielded indices of maximal growth at ages ranging from thirteen to twenty.

Since the tests do not measure raw intelligence or "sheer brain power," there is no way of knowing the actual age at which intelligence stops growing. All one can say is that, somewhere between the early teens and the twentieth year, individuals reach a level of intelligence-test performance which shows no further improvement with age.

Group intelligence tests have been given to large groups ranging in age from ten to ninety years, to determine how intelligence-test scores change as old age is approached. The results of two such investigations are



268 **Curve Showing Changes in Army Alpha Scores as a Function of Age**

(After Jones, H. E., and H. S. Conrad, "The Growth and Decline of Intelligence." Genet. Psychol. Monog., *1933, vol. 13, no. 3, p. 241.)*

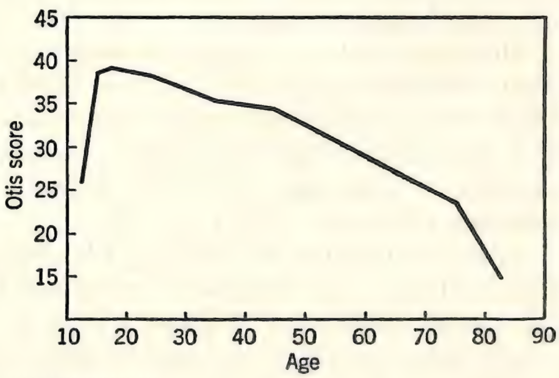
shown graphically in Figures 268 and 269. The data in Figure 268 show that scores on the Army Alpha Test increase until around the nineteenth year and then decline gradually. In Figure 269 we see a somewhat similar increase in Otis Test scores, until the late teens, then a decline. The decline, however, is more rapid than that found with Army Alpha. Moreover, Figure 269 includes data for the years beyond sixty. It shows that the middle seventies bring a very rapid decline in Otis Test scores. This decline is less rapid for some psychological functions than for others.

What we have said about the changes in test performance as old age approaches applies, of course, to groups. It sometimes happens that older persons demonstrate a high degree of test ability. Such persons are rare. What the experiments show is not that the older person knows less as he reaches the higher age levels, but that the readiness with which he acquires further knowledge decreases. When the older adult competes with younger ones and, as is often the case, reaches a similar level of achievement, he usually does so by putting forth a disproportionate amount of effort. It takes him longer to acquire knowledge, and he tends to be more handicapped than the younger person in applying what he has acquired.

FACTORS IN INTELLIGENCE

Versatility in intelligence-test performance is obviously not a unitary process. We have already suggested that intelligence tests measure memory, reasoning, and other processes discussed in earlier chapters. But how many really different abilities are measured? What, in other words, are the primary abilities? Statistical analysis of test performances offers a means of answering this question.

Spearman observed that when different tests are intercorrelated, or parts of tests correlated one with another, the correlations are usually positive.[38] This suggested that the different tests and test items are measuring some common factor. This he called *general intelligence*, or *g*. Spearman claimed that many widely different skills dip, as it were, into this common factor, *g*. Mechanical ability, musical ability, arithmetical



269 **Curve Showing Changes in Otis Group Test Score as a Function of Age**

(After Miles, W. R., and C. C Miles, "The Correlation of Intelligence Scores and Chronological Age from Early to Late Maturity." Am. J. Psych., *1932, vol. 44, p. 51.)*

ability, spelling ability, and many other abilities which show even a slight positive correlation with each other do so, he said, because they all require a certain amount of g. According to Spearman, each skill, in addition to g, calls for specific abilities, or *s*'s. Thus, in addition to requiring a certain large amount of *g*, mathematical skill would require specific mathematical skills (or abilities) which might be facility with numbers, ability to factor, ability to multiply, and so forth. These would be the *s*'s in mathematical performance. Mechanical skill, according to this view, would require a relatively small amount of *g* in addition to mechanical abilities, *s*'s.

Certain other psychologists have taken exception to the claim that there is a single general intelligence factor. They claim that what Spearman has called *g* is analyzable into a number of subsidiary abilities or factors.

Thurstone, for example, has given large batteries of tests, verbal and performance, to high-school and college students. All the students have done all the tests. The score on each test has been correlated with the score on every other test and a table of intercorrelations arranged.

Although most tests correlate somewhat with each other, some tests correlate among themselves much more highly than others. It is assumed that any tests which correlate highly with each other are to a high degree measuring the same ability.

Following this line of reasoning, but using statistical and other devices too complicated for presentation here, Thurstone has recently defined seven factors involved in the performance of a battery of sixty group tests, both verbal and nonverbal.[39] These factors have been designated *verbal comprehension* (V), *word fluency* (W), ability to handle *spatial relations* (S), *number ability* (N), *memorizing* (M), *reasoning* (R), and *perceptual ability* (P). The following samples are from a test designed to measure these primary abilities. The samples indicate the general nature of the skills involved, but they are from some of the preliminary tests, hence the easiest ones. There are twenty-one different tests in the battery, three for each factor. Each of these tests has a large number of items.

Verbal Comprehension (V)

Think of a sentence using the words below. Then mark the first and last words in that sentence.

was late he school for

The following sentence has a word missing at the place indicated by the parentheses. You are to think of the word that best completes the meaning of the sentence. The number in parentheses is the number of letters in the missing word. Mark the first letter in the missing word.

A (9) is a place or building for athletic exercises.

C— D— G— H— T—

Word Fluency (W)

Each of the words in the list below has four letters and begins with B.

bear bone bald bent

Write as many words as you can which have four letters and begin with C.

Look at the words in the following list. Each of them ends with *able.*

capable valuable comfortable

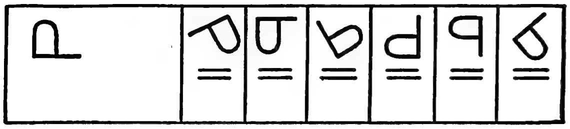
Write as many words as you can which end with *tion.*

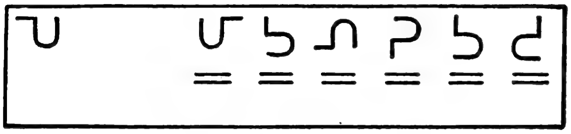
Spatial Relations (S)

Look at the row of figures below. The first figure is like the letter F which is right side up. All the other figures are like the first, but they have been turned in different directions.

Satisfy yourself that all these figures look like the first one if they are turned right side up.

In each row of figures below, mark the figure which is like the first figure in the row. Do not mark the figures which are made backward.





Number Ability (N)

In the row of numbers below, 10 is marked because it is three more than the number 7, which is just before it. The number 8 is also marked because it is three more than the number just before it.

5 7 <u>10</u> 12 14 11 3 5 <u>8</u> 12

In the row below mark every number that is exactly three more than the number just before it. Work as fast as you can.

15 19 21 26 29 22 25 5 8 7 11 4

Below are two multiplication problems which have been worked out. Multiply the numbers for yourself to see if the products are correct.

64	39
7	4
448	166
R	R
W	W

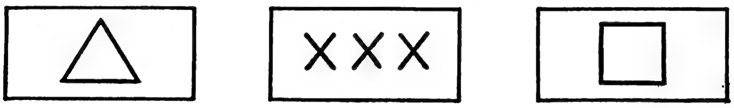
The first answer is right, so the R below it is marked. The second answer is wrong, so the W is marked.

Below are two columns of numbers which have been added. Add the numbers for yourself to see if the sums are correct.

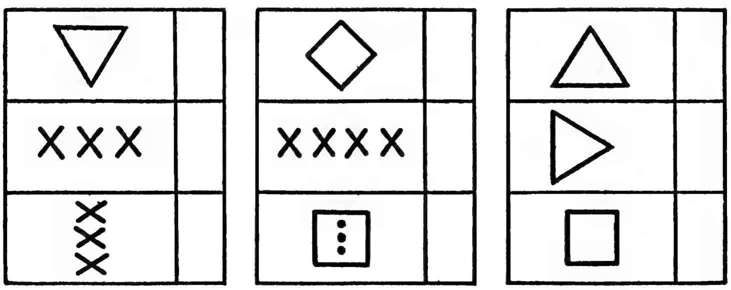
16	42
38	61
45	83
99	176
R	R
W	W

Memorizing (M)

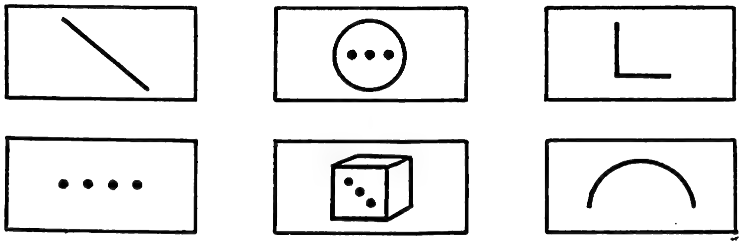
Study the figures below so that you can recognize them when you see them again.



In the list below put a check mark (√) after each of the figures that are listed above.



The list below is studied in a similar manner so that the testee can check these figures when he sees them again on the next page of the test.



In each row below is written a name. You are to learn the names so well that when the last name is given you can write the first name. On the next page the last names are listed in a different order. You will be asked to write the first names.

First name	*Last name*
Mary	Brown
John	Davis

etc.

Reasoning (R)

Look at the groups of letters below.

AABC ACAD <u>ACFH</u> AACG

Three of the groups have two A's. The group which does not have two A's is marked.

Here is another problem. Three of the groups are alike in some way. Can you find three groups which are alike?

XVRM ABCD MNOP EFGH

Read the row of letters below.

abababab ___

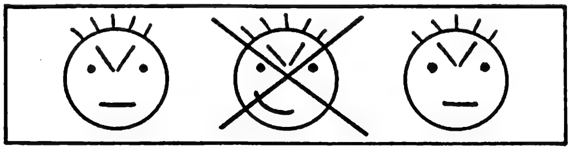
The next letter in this series would be *a*. Write the letter *a* in the blank at the right.

Now read the next row of letters and decide what the next letter should be. Write that letter in the blank.

cadaeafa ___

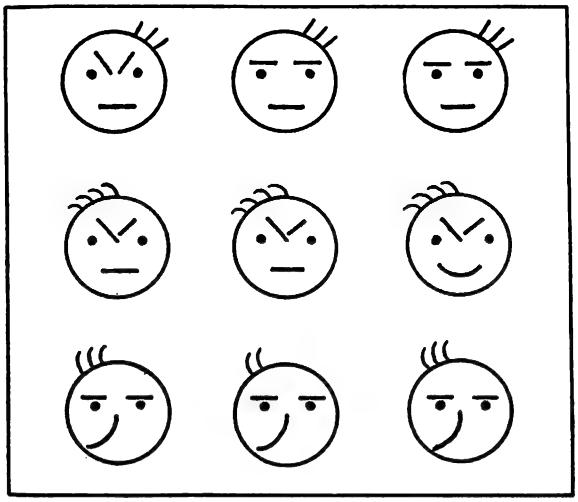
Perceptual Ability (P)

Here is a row of faces. One face is different from the others. The face that is different is marked.



Look closely to be sure that you see why the middle face is marked. The mouth is the part that is different.

Here are some more pictures. In each row mark the face which is different from the others.



Look at the two words below.

cat 

The first word is *cat*. The second is also *cat*, but it is printed backward.

In each column of words below, mark the word printed backward which is the same as the first word.

lamp	purse	horse	most
look	purse	bunch	more
lamp	phrase	horse	most

The tests from which these samples have been taken were each designed to measure one primary ability and little else. These seven primary abilities are not the only factors involved in intelligence-test performance, but Thurstone feels that they are the ones most clearly identifiable in the batteries of tests analyzed by him over a period of several years. Speed, learning ability, and several other functions which one might expect to be involved in intelligent behavior are not identified, but this is perhaps because the tests have not been designed to measure these functions.

The value of measuring primary abilities instead of a heterogeneous integration of such abilities as in most intelligence tests is probably obvious. There are certain skills, like mechanical skill, which have a low correlation with scores on tests of "general intelligence," yet which might correlate highly with a particular primary factor (or group of primary factors). A test of this factor (or group of factors) might then be useful in selecting those with mechanical skill. It might serve, in other words, as part of a battery of tests, some of which measure more specific mechanical skills.

SUMMARY

Intelligence is a function which, in general, we have defined as versatility of adjustment. We have stressed the fact that the superiority of human intelligence is especially evident where symbolic activities are involved.

The first intelligence tests were designed to select children who had insufficient intelligence to profit from regular education. Intelligence tests have continued to be useful in this respect. Tests designed for use with babies are being standardized in the hope that they will enable adoption agencies to avoid placing the feebleminded. Tests have also been designed especially for adults.

The first tests were devised by Binet and Simon. These were later standardized for use in testing American school children. Although there were many standardizations in addition to the American (English, German, and so on) and several American standardizations, we have described only the Stanford-Binet, which is most widely used in this country.

Items for the test were not selected arbitrarily, but were selected only after a tryout on many school children. The nearly three thousand school children on whom the final forms of the test were standardized attended schools rated as average in their community. This is an important point to remember, for, unless a child has had average opportunities to learn, the mental age (M.A.) and the intelligence quotient (I.Q.) determined with this test are practically meaningless. A child whose educational opportunities have been average, and who does as well on the Stanford-Binet Test as the average child of his age, has an I.Q. of 100. If the child exceeds his age group in performance, his M.A. is higher than his C.A. and consequently his I.Q. is higher than 100. On the other hand, a child who does more poorly than children of his age group has an M.A. lower than his C.A. and an I.Q. below 100.

When a normally healthy school child whose educational opportunities have been average is tested year after year, his I.Q.

remains fairly constant. I.Q.'s determined before the school age tend to fluctuate a great deal, hence are generally not regarded as reliable. Changes in educational opportunities lead to fluctuations in I.Q. There are cases on record, too, where the I.Q. rose considerably after glandular therapy.

Our consideration of the claim that intelligence is an innate capacity led us to conclude that the ability to develop intelligent behavior (that is, the ability to develop versatility of adjustment) may be innately determined to a large degree, but that intelligence as such is dependent upon both heredity and environment. We expressed an hereditarian bias here, by claiming that, in general, differences in heredity are responsible for larger differences in intelligence than can be attributed to differences in environment.

The chief values of determining a child's I.Q. are that (1) those of low I.Q. can be weeded out for special education in line with their capacity to acquire intelligent behavior; (2) those of very high capacity can be selected for education in keeping with their capacity; and (3) parents and others may more wisely give vocational guidance if they know a child's I.Q.

Performance tests require a minimal degree of verbal ability. There are tests of this variety for individuals ranging in age from infancy to the adult level.

Group tests (verbal or performance) can be given and scored by individuals with little training, and they may be given to large numbers at a time. They are especially useful when conditions preclude giving the more reliable, but time-consuming, individual tests. The scores on group tests are usually reported in terms of percentiles. One's percentile score indicates the per cent of individuals whom he excels on the test.

Intelligence-test performance improves with age, up to somewhere between the early teens and the twentieth year. The age of maximum performance differs within these age limits for different tests. There is eventually a decline in intelligence-test performance with age. This decline usually becomes very rapid as old age approaches.

Factor analysis is an attempt to determine how many primary abilities are involved in intelligence-test performance. It starts with tables of intercorrelations and involves procedures too complicated for presentation to beginners in psychology. Spearman believed that there is a general intelligence factor (*g*) involved in all intelligence-test performances, and in many other skills. According to this view, there are also specific factors, or *s*'s. The more widely accepted view today is that "general intelligence" is a composite (or integration) of several primary functions (or factors). Among the primary functions already identified are: verbal comprehension (V), word fluency (W), spatial relations (S), number ability (N), memorizing (M), reasoning (R), and perceptual ability (P).

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23 APTITUDES

Degrees of Aptitude • Aptitudes, Inborn Capacities, and Present Abilities • Aptitude and General Intelligence • Aptitude and Interests • Mechanical Aptitudes • Developing Tests of Aptitude for Particular Jobs • Musical Aptitudes • Vocational Guidance and Selection • Human Aptitudes and Engineering Design • Summary.

Aptitudes are inferred from individual differences in acquiring proficiency. A student who takes to college work "like a duck to water," making good grades with only reasonable effort, is said to have a high degree of aptitude for college work. On the other hand, a student who, despite the best efforts he can put forth, and despite the best efforts of his teachers, cannot "make the grade," is said to have little aptitude for college work.

One child takes quickly to musical training, and progress is evident almost from the start. Another child given the same training makes little or no progress. The first may be said to have musical aptitude to a high degree and the second little musical aptitude. If the first child should turn out to be a musical prodigy, we should say that he had exceptional aptitude for music. We might be even more complimentary and say that he was musically talented or gifted.

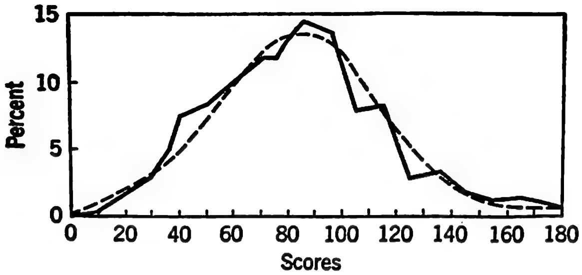
Consider a girl who goes to business school in order to become a stenographer. If she progresses rapidly with her typing and shorthand and is graduated, in the minimum time, to a job which she carries out efficiently, we may say that she has a high degree of aptitude for stenographic work. If, on the other hand, she fails to meet the minimum standards for stenographic work in the time allotted, we are justified in saying that she has little aptitude for stenographic work.

To use one more illustration, take a college student who enters training designed to equip him for life insurance underwriting. If he readily learns the requisite techniques and is soon selling respectable amounts of life insurance, we may say he has aptitude for this work. If he fails the course, or passes it and has difficulty in meeting or talking to people, and thus sells little insurance, we look upon him as possessing little aptitude for this field.

One practical problem confronting a tester of aptitudes is how to select, before training, those who will most likely succeed in a particular occupation. If he can do this, much time and effort ordinarily expended with the potentially unsuccessful can be saved.

DEGREES OF APTITUDE

Aptitude, like intelligence, is inferred from relative levels of achievement. If individuals given comparable opportunities to acquire some skill differ in the ease of acquiring it, or if they differ in the level of proficiency attained, we say that they differ in their aptitude for that particular work. Again like intelligence, aptitude is distributed over a wide range. At one extreme are those with little aptitude for the work in question.



270

Distribution of Scores Made on a Number-Checking Test by 438 Men Compared with a Normal Distribution

(From Green, H. J., E. R. Bergman, D. G. Paterson, and M. R. Trabue, "A Manual of Selected Occupational Tests." Bulletin of the University of Minnesota Employment Stabilization Research Institute, *1933, vol. 11, no. 3, p. 28.)*

These are few in number. At the other extreme are those with maximum aptitude for that work. They are also few in number. Those with an intermediate degree of aptitude for the activity in question are, of course, most frequent. A distribution of degrees of aptitude is illustrated in Figure 270. This shows the per cent of 438 men making particular scores on a number-checking test, which is part of a battery of aptitude tests for clerical workers. A normal distribution curve is superimposed upon the actual frequency distribution curve to demonstrate how closely such a curve is approximated in the group tested.

Aptitude, moreover, is more or less specific. That is to say, an individual may have aptitude for one line of work, but not for certain others. One may have a high degree of aptitude for college work, but a low degree of aptitude for music; a high degree of aptitude for bookkeeping, but a low degree of aptitude for mechanical work; or a high degree of aptitude for teaching, but a low degree for flying. Some people have a wide range of aptitudes and others a very narrow range. The former can learn to do many things well; the latter can learn to do only a few things well.

Just as performance on a test of general intelligence may be factored into a variety of mental activities (pp. 537–541), so tests of aptitude for a particular vocation may usually be factored into a number of subsidiary aptitudes. As a matter of fact, aptitude for most vocations is often measured. not by one test, but by a battery of tests.

APTITUDES, INBORN CAPACITIES, AND PRESENT ABILITIES

Aptitude does not necessarily mean innate capacity. You might have an I.Q. of 180 resulting, in part, from superior native endowment. But this would not necessarily give you aptitude for college work. Your early training may have given you a slant on college work and college people that makes college distasteful to you. If your parents coerced you into going to college, you might spend your time on extraneous activities and make poor progress. A student with much lower intelligence, but who wanted to go to college and who used his ability to the best advantage, might easily outdistance you in the quality of his work. His greater aptitude would come, not from superior endowment, but from the attitude that early training contributed.

It should not be gathered from this, however, that aptitudes are completely independent of inborn capacities. It may well be that musical aptitudes and mechanical aptitudes of various kinds are closely related to innate endowment.

Some have claimed that ability to profit from musical training — that is to say, aptitude for music — is limited by the sort of ear, and perhaps brain structure, with which the individual has been born. Suppose, for example, that your basilar membrane or its neural connections with the brain were so constituted that you were unable to discriminate fairly small differences in pitch and intensity. No amount of musical training would make a good musician of you.

Long before the days of aptitude tests in music, the writer was given a piccolo and an opportunity to join the school band. Although he practiced assiduously, the bandmaster was always accusing him of making the sour notes which disturbed the total symphonic effect. He was soon asked to leave the band, and even his parents finally persuaded him that production of pleasing music was not in his line. More than twenty years later, he took the Seashore Test of Musical Talent and found himself in the lowest percentile in pitch discrimination. In other words, almost anybody has better pitch discrimination than he. If the test had been given before the piccolo was bought and the training begun, he could have avoided much discomfiture to others and much disappointment to himself.

Some children are endowed with longer fingers and more dexterous hands than others. When it comes to such skills as making watches, playing the piano, or perhaps even performing certain kinds of surgical operation, these individuals have an inborn advantage over those with short stubby fingers and clumsy hands — the so-called "ham-handed."

But not all psychologists would agree that there is anything to the idea of innate differences in aptitude, or innate capacities for particular lines of work. Here is what Watson, one of the most extreme of the dissenters, said about the idea:[1]

> Give me a dozen healthy infants, well-formed, and my own special world to bring them up in, and I'll guarantee to take any one at random and train him to become any kind of specialist I might select — doctor, lawyer, artist, merchant-chief, and, yes, beggar-man and thief, regardless of his talents, penchants, tendencies, abilities, vocations, and the race of his ancestors.

Watson tacitly admits inborn differences in structure, however, when he speaks of a child who, in the present nature of things, could not become a skilled pianist.

> His fingers were not long enough and the muscular arrangement of the hand was not flexible enough. But even here we should be cautious — the piano is a standard instrument — a certain finger span and a certain hand, wrist, and finger strength are needed. But suppose the father . . . had said, "I want him to be a pianist and I am going to try an experiment — his fingers are short — he'll never have a flexible hand, so I'll build him a piano. I'll make the keys narrow so that even with his short fingers his span will be sufficient, and I'll make a different leverage for the keys so that no particular strength or even flexibility will be needed." Who knows — the . . . son under these conditions might have been the world's greatest pianist.[2]

We cannot, of course, remake the artistic, business, or industrial world to fit the peculiar needs of individuals such as the child mentioned by Watson. Judged by present standards, that child would be said to have little or no aptitude for piano playing. It is immaterial whether such ineptness results from an inborn hand structure, making for poor manual dexterity, or from lack of a suitable instrument. As the case is stated by Watson, it results from both. Likewise, aptitude for any of the aspects of the world's work might depend on inborn characteristics, acquired interests, early training, or a combination of these. The fact would still remain that some acquire certain skills more readily than others and reach higher levels of accomplishment than others. In saying that they have greater aptitude than others, we are merely putting these facts in a nutshell without saying to what degree the differences are innate or acquired. As one of our leading authorities on aptitude testing has so well pointed out:[3]

> We want the facts about a person's aptitudes as they are at present: characteristics now indicative of his future potentialities. Whether he was born that way, or acquired certain enduring dispositions in his early infancy, or matured under circumstances which have radically altered his original capacities is, to be sure, a ques-

tion not only of great theoretical interest, but of profound importance to society at large; for the answer has a bearing on public policy in regard to universal education, the functions of the school, and eugenic legislation. But it is of little practical moment to the individual himself at a time when he has already reached the stage of educational and occupational planning. His potentialities at that period of his development are quite certainly the products of interaction between conditions both innate and environmental. His capacity for gaining manual skills, his intelligence, his emotional makeup, his moral character, indeed all aspects of his personality, are in varying degrees subject to limitations that have been imposed by opportunities for growth and exercise, as well as by his original nature. No matter what his constitution may at first have been, it has unfolded, taken shape, been encouraged here and thwarted there, during the impact of favorable or unfavorable stimulation from the environments in which he has developed. And so, when appraising his aptitude, whether for leadership, for selling, for research, for artistic design, we must take him as he is — not as he might have been.

From what we have already said, it is perhaps clear that aptitude and present ability do not mean the same thing. You may have no present ability to fly a plane, but you may have a high degree of aptitude for flying — which means that your chances of being a successful flyer are good, provided you receive the proper training. The chief value of aptitude testing is, in fact, that it enables us to pick out from those who do not yet have the ability to perform certain skills those who, with a reasonable amount of training, will be most likely to acquire the skills in question and acquire them to a desirable level of proficiency.

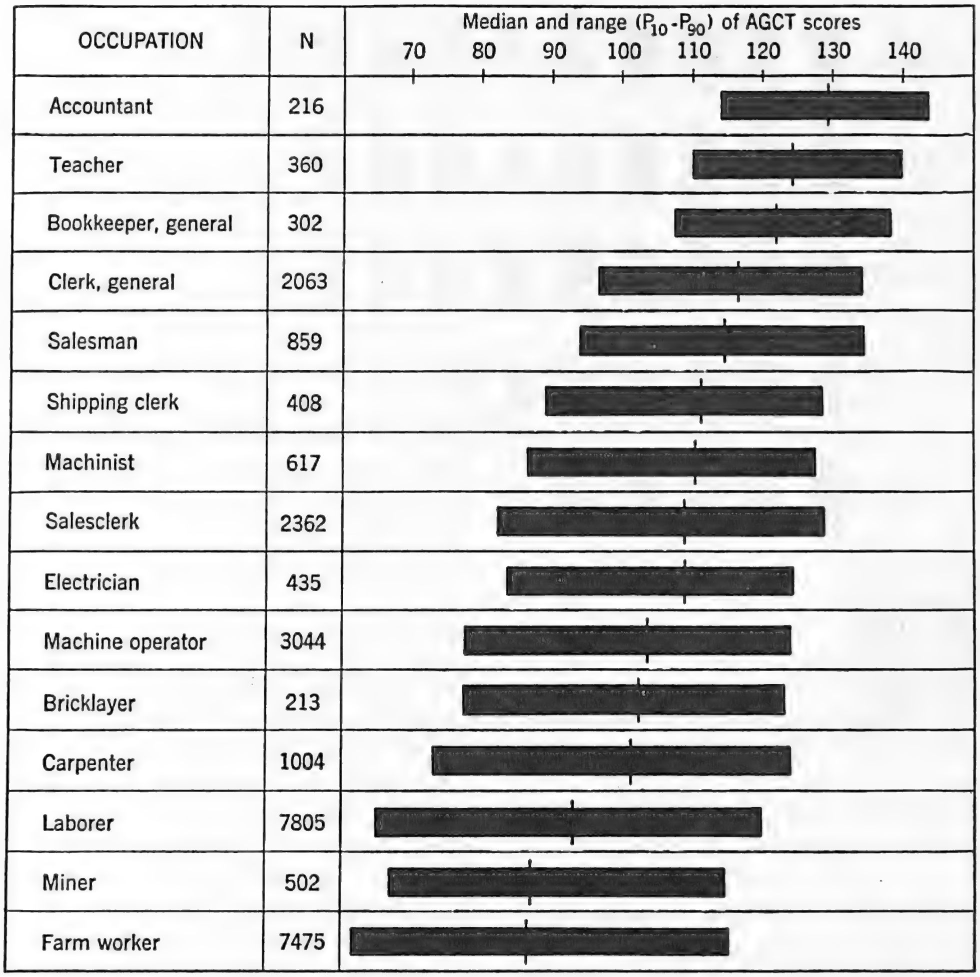
There are two main general reasons for attempting to measure aptitudes. One of these is to advise youth concerning the fields of activity in which they are most likely or least likely to be successful. The other is to select those best fitted for particular jobs. The first-mentioned application of aptitude testing is in the interest of *vocational guidance;* the second is in the interest of *vocational selection.* Although these aims are different, the tests used may be identical. The difference lies in the reason for giving the tests and the uses to which they are put.

APTITUDE AND GENERAL INTELLIGENCE

Performance on intelligence tests is sometimes indicative of aptitude for certain lines of work. Indeed, the use of intelligence tests in both world wars was for the purpose of selecting, from the millions drafted, those who would be most likely to profit from specialized forms of training. Selectees in the recent war were given an opportunity to enter the pilot training programs only if they made higher than a certain score on specially devised intelligence and information tests. Individuals allowed to participate in the Army Specialized Training Program and other college training programs were also selected partly by use of intelligence tests.

High scores on good general intelligence tests do tell us about the probability of success in college work. Here is an illustration of what happens when only those making high grades on intelligence and achievement tests enter college. The writer taught a class of seventy-six ASTP premedical students and, on objective examinations which usually yielded a normal distribution, with percentages of correct answers ranging from about 40 to 95, these students all rated above 75 per cent. Most of them made scores of 80 per cent or better. One instructor, who apparently did not know that these students were selected on the basis of college aptitude tests, worried because he was not able to "grade on the curve." In one of his exams in chemistry, all made around 90 per cent or better.

One of the best single aptitude tests for college work is a good test of "general intelligence," designed to select in terms of



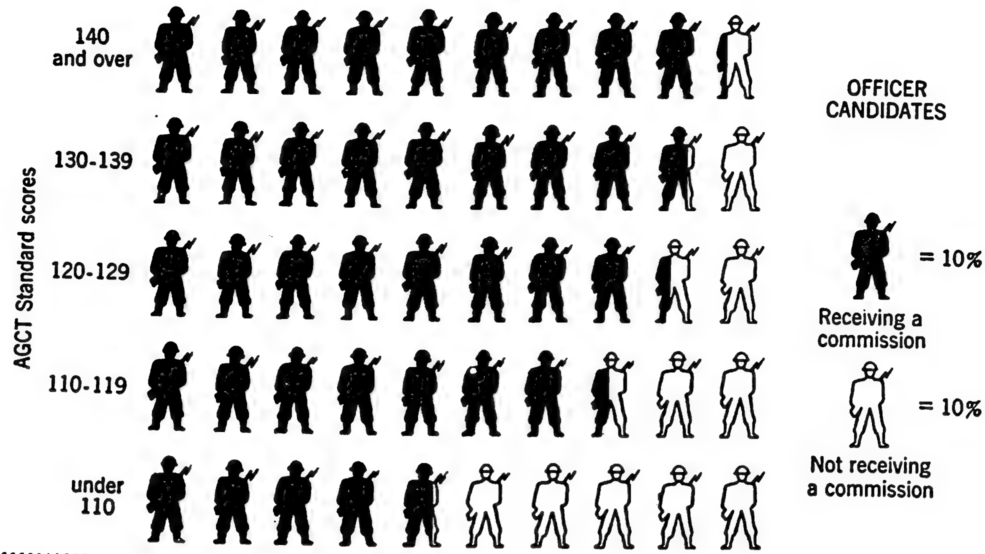
271

AGCT Scores for a Selected Group of Occupations

The group represented comprised 81,553 randomly selected white enlisted men. Each bar shows the range between the 10th and 90th percentiles for selectees in that occupation. The vertical bars represent median scores. (After Anastasi and Foley from data reported by Stewart.)

scholastic aptitude. Where such tests are used to pre-select students, the per cent of students dropping out in their freshman year or later is sharply reduced from that expected in a less well selected class. With personality and interest tests added, it might be cut still more. There are, of course, always some who drop out for other reasons than lack of aptitude for college work.

General intelligence is also related, but not in so obvious a manner, to many other lines of endeavor. For certain kinds of work, high intelligence might even be a handicap. Some concerns will not employ persons for certain jobs if their intelligence-test performance is above average. Although they are able to do the work satisfactorily, those with above average intelligence tend to become discontented and to leave the job for something else.



272

Predicting Success of Officer Candidates from Their Grades on the AGCT Test

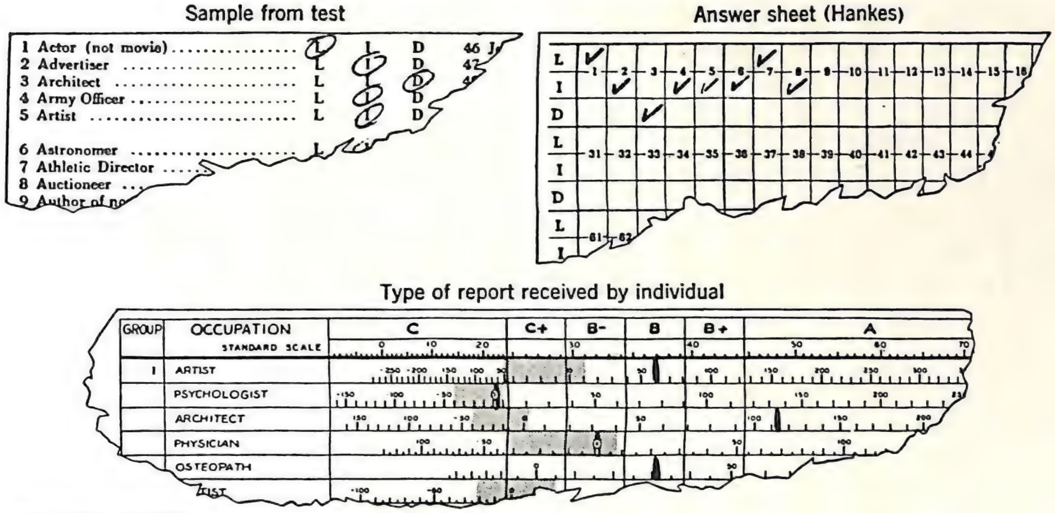
This figure shows the per cent passing the officer training course and receiving a commission. (From Boring, E. G., Editor, Psychology for the Armed Services. *Washington: Infantry Journal Press, 1945, p. 242.)*

Then there are certain jobs which cannot be performed successfully by most individuals below a certain minimum intelligence. A suggestion of the limits of intelligence of individuals employed in various kinds of work ranging from unskilled to professional work is given by the data in Figure 271. These are based upon AGCT scores (p. 532). Observe, for example, that accountants have a median score (not I.Q.) of about 130 and that miners have a median score of around 90. Overlapping of the range of scores is typical of many occupational groups.[4]

In using the results of intelligence tests for vocational guidance purposes, we might well say to an individual whose score is 75 (Figure 271) that the chances are high that he will not succeed if he attempts to enter an occupation above the level of bricklayer or machine operator in the hierarchy illustrated. We might say to him, on the other hand, that he possesses sufficient ability to consider going into occupations from the level of carpenter down.

One occupational use of the AGCT scores in the armed services is illustrated in Figure 272. Here we see that over 90 per cent of the candidates for officer training who were in the upper rating (see Figure 267, p. 532) actually became officers. The percentage of successful candidates decreased as the test scores decreased. Of those in the lowest Army grade (Grade V, scores under 110), less than 50 per cent passed the course. By setting the lower limit (cut off score) at 110, the authorities saved much time, effort, and expense that would otherwise have been devoted to potential failures.[5]

Other things than intelligence are also important, but at least there appears to be an appropriate minimum intelligence required for success in certain occupations, including those in the armed services. If the individual were below that minimum, we would certainly advise against attempting to enter that occupation. If he had above the minimum intelligence, we would then examine other performances that seem



273

The Strong Vocational Interest Blank

Observe that one fills out the blank by encircling the L *if he likes, the* D *if he dislikes, or the* I *if he is indifferent to the particular occupation. If an answer sheet, for machine scoring, is used, he checks the* L, I, *or* D *in the appropriate column. The report finally obtained grades the individual from* C–A *for each of many occupations. (Courtesy of Engineers Northwest, Minneapolis.)*

important in that occupation. We might want to test for mechanical aptitude, medical aptitude, art aptitude, or the like, depending upon what it is the individual is interested in doing.

In selection of individuals for certain jobs, a minimum intelligence score is sometimes set and all those who fail to reach it are denied admittance. This score is usually set at a point higher than the minimum for the occupation. There is the danger that some are eliminated who might succeed despite their low score. But what the personnel director or the Army General Staff tries to do is to set a score which, as indicated by preliminary experimentation, will give the highest percentage of potentially successful individuals, without eliminating too many who might be successful.

APTITUDE AND INTERESTS

One of the best single indicators of possible success in certain occupations is the way in which the interests of candidates compare with those of people who are successful in these occupations. It is, of course, possible for a person to be interested in something, like being a salesman, yet have little or no aptitude for it. Nevertheless, in choosing a group of salesmen who would, as a group, be successful, the interest inventories are very useful.

One well-known and most widely used vocational interest inventory is Strong's Vocational Interest Blank. In filling out this blank, a person indicates his "like," "dislike," or "indifference" for a wide range of occupations, amusements, school subjects, sports, and undertakings, as shown in Figure 273. There are 400 items in all. The responses are then scored with keys designated "Artist," "Psychologist," "Architect," and so on. There are separate blanks and scoring keys for men and women. The key for "Artist" is based upon the predominant reactions of successful artists to items in the interest blank. Likewise, each of the twenty-seven

keys for male occupations and the seventeen keys for female occupations is based on the predominating reactions of individuals in those occupations. A sample report and its analysis is also shown in Figure 273.

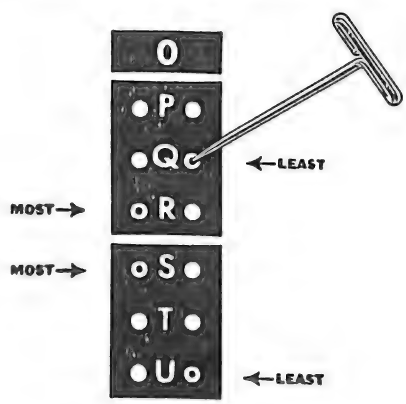
Strong found that those who succeed as real-estate salesmen, for example, have a pattern of likes, dislikes, and indifferences which differs from that of those successful in certain other occupations. A person whose pattern of interests closely coincides with that of successful architects has a leaning, at least, in the direction of being a good architect. The person whose interests are represented in Figure 273 rates A for interest in architecture, and only C for interest in psychology. His interests are thus predominantly like those of architects and not much like those of psychologists. His architectural leaning does not guarantee, of course, that he will succeed in this occupation, but it suggests the probability that he will like the work and succeed in it better than in other occupations, including psychology, where his interests do not lie.

The Kuder Preference Record is another widely used interest inventory. It is scored for types of occupation rather than for particular jobs. Interest scores are reported for the following occupational areas: outdoor, mechanical, computational, scientific, persuasive, artistic, literary, musical, social service, and clerical. An interesting feature of the inventory is that it is self-scoring. In reacting to the many items, arranged like those of Figure 274, the subject punches a hole with the pin illustrated. He punches a hole to the right of the activity that he likes least of the three, and to the left of the activity that he likes most. As the holes are penetrated, the point punches underlying score sheets containing a different pattern of circles for each interest area. The number of punched circles on the sheet for "outdoor" is then counted, then the number on the sheet for "mechanical," and so on. The resulting scores are finally translated, from a table, into percentiles. These are plotted to form interest profiles like those shown in Figure 275. Here we compare the mean profiles of men who are, respectively, high school teachers of social science and airline pilots. Observe that the teachers rate below the 25th percentile on mechanical interests while the pilots rate above the 75th percentile. The teachers rate highest on social

Put your answers to these questions in column O.

P. Visit an art gallery . . . .
Q. Browse in a library . . . .
R. Visit a museum . . . .

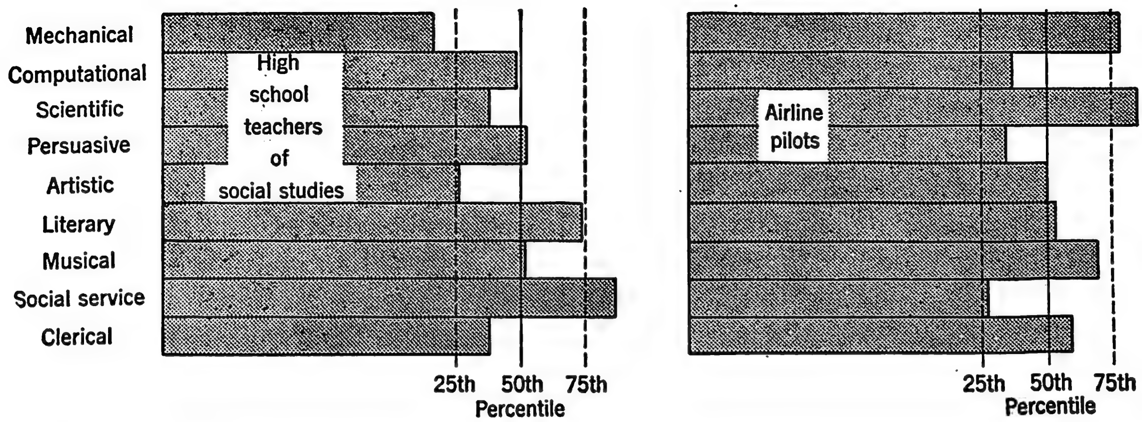
S. Collect autographs . . . .
T. Collect coins . . . .
U. Collect butterflies . . . .



274

Items from the Kuder Preference Record

Of the alternatives P, Q, *and* R, *this person likes* Q *least and* R *most. He likes* S *most and* U *least of the alternatives* S, T, *and* U. *The pinprick is an automatic marking device since the pricks fall into various patterns on a score sheet below. (Courtesy of Science Research Associates, Chicago. © G. F. Kuder.)*



275 **Mean Profiles of Men in Various Occupations**

The solid line across each chart is the 50th percentile; the 25th and 75th percentiles are represented by dotted lines. (Courtesy of Science Research Associates, Chicago. © G. F. Kuder.)

interests, whereas the pilots rate highest on scientific interests. The reader will observe other interesting differences in the respective ratings of these groups.[6]

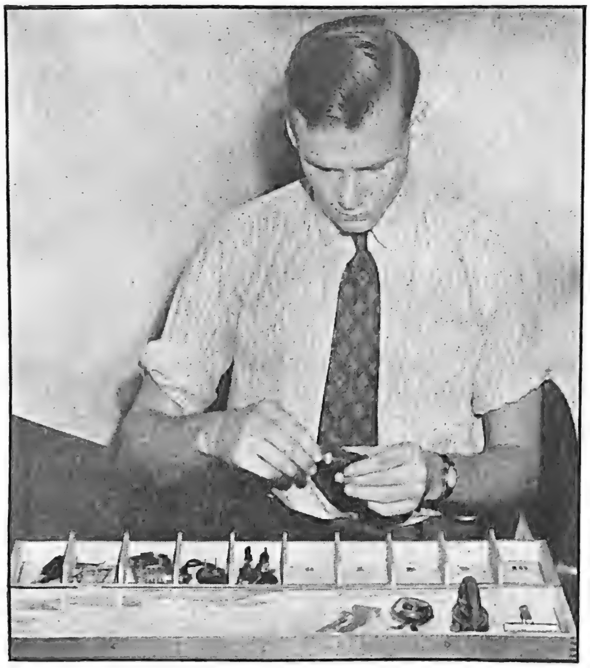
MECHANICAL APTITUDES

Many civilian and service jobs require people with mechanical comprehension and manipulative skill. Unless mechanically inept individuals are eliminated at the outset, much equipment is wastefully tied up and a great deal of time, effort and money is squandered on those who would be more successful and happier in preparing for some other occupation. Tests of mechanical comprehension and dexterity, or manipulative skill, are used to select people who can readily learn new mechanical skills.

Many mechanical aptitude tests have been developed. These are arranged in different combinations, or batteries, depending upon the kind of work for which trainees are to be selected. One type of mechanical aptitude test is like that illustrated in Figure 276, A. This requires the subject to assemble a variety of items as quickly as possible. The devices to be assembled in these tests include such things as a mouse trap, a door bell, a lock, and a wrench. When designed especially for a given industry, such tests may comprise items to be found in that industry.

Some tests, like that shown in Figure 276, B, are used to measure such aspects of behavior as comprehension of spatial relations, speed of reaction and manipulative skill. If a more precise dexterity, involving precision of finger movements, is required for a particular job, then very small objects, such as nuts and bolts, are manipulated in various ways, as shown in Figure 276, C. Sometimes tweezers are used instead of the fingers alone (see p. 558).

Most mechanical aptitude tests are given to one individual at a time, but they are sometimes given to groups, as illustrated in Figure 277. This figure shows a test widely used during the war as part of a battery to select aircraft pilots. Good performance requires accurate, rapid and coordinated movements of both hands simultaneously. There is an upper and a lower disk. Movements of the upper disk are controlled by the handles, the right handle moving it from



A

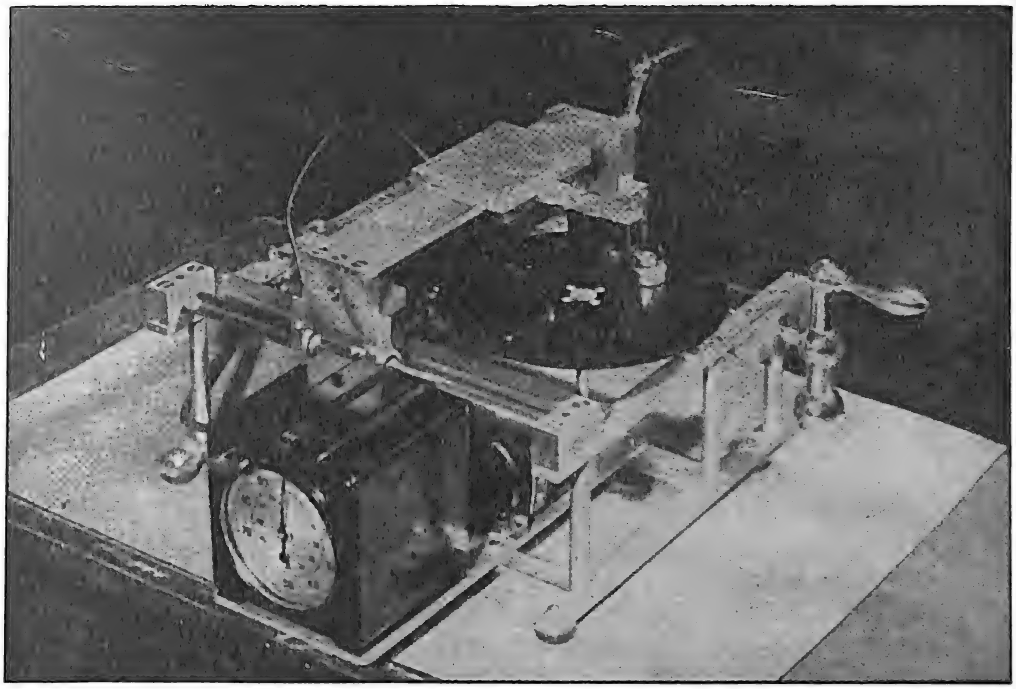
B

C

276

Some Mechanical Aptitude Tests

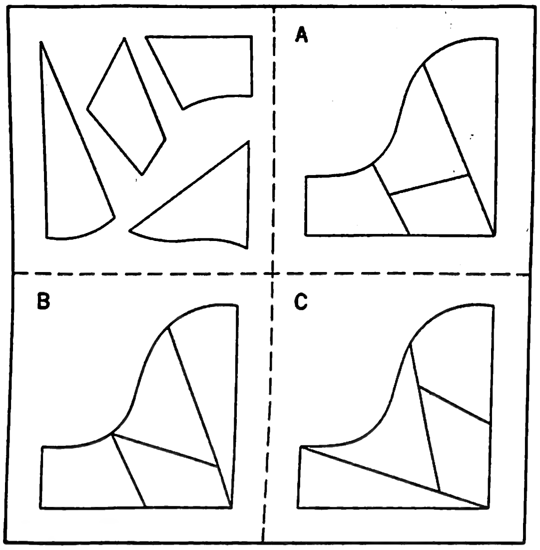
A. A form of the Minnesota Assembly Test. Each common article (electrical plug fixture, mousetrap, etc.) is to be assembled as rapidly as possible. *B.* This Peg-Board test examines manual dexterity by requiring the man to pick the pegs out of one side of the board and put them down in the same pattern in the opposite corner of the board. From a battery used by the U. S. Employment Service. (Courtesy of U. S. E. S.) *C.* Here the testee is timed while he puts a nut on each bolt, places each assembly in the appropriate hole, then removes the nuts. (Wide World Photo.)



277

Two-Hand Coordination Test Used in Pilot Selection

Here the individual attempts to move both handles at the same time in such a manner as to keep the upper disk over the lower one, which moves in an unpredictable manner. One method of scoring is to record the time, in a standard period, that one disk is over the other. The chronoscope illustrated in the top picture is that of the Standard Electric Time Co., Springfield, Mass. (From *The Aircraft Pilot.* Washington: CAA, 1945, p. 6. Lower picture from Melton, A. W., "The Selection of Pilots by Means of Psychomotor Tests." *J. Aviation Med.*, 1944, vol. 15, p. 119.)



278

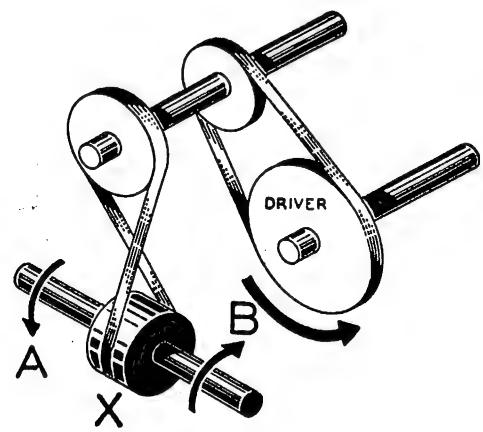
The Minnesota Paper Formboard

This item is not from the actual test, but simulates those in the test.

right to left and the left handle moving it toward or away from the subject. By an appropriately coordinated series of movements, the disk may be moved anywhere above the turntable. The lower disk moves in a pattern known only to the tester. When one disk is over the other, an electrical contact with the chronoscope is made, the greater the time that the two disks are in contact, the higher the subject's score.

The chronoscope illustrated in Figure 277 is a modern version of the type of instrument described in Chapter 1 (p. 11). When fitted with stimulus and response keys, it may be used to measure the subject's speed of reaction. When the tester presses his key, he gives a stimulus for reaction and also starts the chronoscope. The pointer revolves, marking off hundredths of a second, until the subject reacts. His reaction breaks the contact, and the pointer stops. For selection purposes, the subject's speed of reaction to complicated stimuli, or the time consumed in complicated tasks, is more significant than the speed of reaction to some simple stimulus, like a click or the flash of a light. Speed of reaction to stimulus situations such as a person might meet on the highway are often involved in driver aptitude tests.

There are also pencil and paper tests of mechanical aptitude. They are designed to be given to large groups and scored with keys or scoring machines. One of these is the Revised Minnesota Paper Formboard. Figure 278 shows an item simulating those in this test. The individuals being tested are required to indicate whether the pieces in the upper left-hand corner, when fitted together, produce A, B, or C. There are sixty-four problems like this, but much more complicated, in each of the two forms of the test. Figure 279 gives one of the items from a form of the Bennett, Seashore and Wesman Mechanical Reasoning Test, a type of test widely used to select persons fitted for a variety of mechanical occupations, includ-



279

Sample Item from Form B of the Bennett, Seashore and Wesman Mechanical Reasoning Test

The subject marks A *or* B *in the test booklet in response to the written question which appears with each pictured situation. In this case, the question is: "If the driver turns in the direction shown, which way will the pulley at 'X' turn?" (Courtesy of The Psychological Corporation, New York City.)*

ing flight performance. In each case the individual being tested is asked to make a response requiring mechanical judgment.

DEVELOPING TESTS OF APTITUDE FOR PARTICULAR JOBS

It often happens that general aptitude tests like those already described must be modified or supplemented with other tests before a satisfactory measure of aptitude for certain skills can be obtained. In the Second World War, the Army Air Force psychologists, for example, did not have ready-made tests of aptitude for the jobs of pilot, bombardier, and navigator. It was necessary to devise such tests. Psychologists in the Bureau of Aeronautics of the Navy Department had to do likewise. Psychologists in business and industry, when called upon to select people for special jobs, must also adapt tests already in use, combine these tests into new batteries, or devise completely new tests.

In devising an aptitude test, or battery of such tests, the general procedures followed are: (1) analysis of the job for which the tests are to be used; (2) tentative selection and arrangement of items which appear to measure the psychological processes disclosed by the job analysis to be important for that job; (3) development of a standardized method of administration and scoring; (4) administration of the test to a large and representative group of individuals from the population on which it is finally to be used; and (5) analysis of results to discover whether the tests are good predictors of success in the occupation for which they are designed.

Job analysis. Regardless of whether an aptitude test is devised for vocational guidance or for vocational selection, the first thing that the psychologist usually does before designing it is to make a detailed analysis of the psychological processes required in successful performance of the job in question. Before designing certain tests of flying aptitude, psychologists went aloft with experienced pilots, bombardiers, and navigators. While aloft, they observed the pilot, bombardier, or navigator's performance. Some of them went through the training process themselves, paying particular attention to the kinds of processes they were called upon to use. After gathering relevant information on the requirements of the job in this and other ways, they were then ready to design batteries of aptitude tests for pilots, bombardiers, and navigators. Similarly, psychologists have gone into industry and observed skilled performance or learned the performance themselves. One psychologist who was called on to develop a test of aptitude for streetcar operators observed skilled operators and also learned to operate a streetcar himself before developing his test.[7]

Tentative selection of test items. After a job analysis has been completed and some insight into the nature of the processes required has been gained, the psychologist then selects tests from those already available or devises tests to measure these processes. Suppose a certain level of intelligence seems important, then he may try out one or more of the many intelligence tests available. Suppose that calmness under conditions of stress is one of the requirements, then he may try out some of the devices used in the laboratory to record physiological changes in emotion. Suppose that hand-steadiness is involved, then he may try out a test of hand-steadiness. Suppose that ability to react quickly to a stimulus seems important, then he may test speed of reaction with a chronoscope. Suppose that a certain kind of finger dexterity seems to play an important role, then he may try out tests like that illustrated in Figure 280. If certain personality traits seem to be important, then he may try out one or more of the personality tests already available. If the individual's interest in the occupation, or

280

The Crawford Small Parts Dexterity Test

Working as rapidly as possible, the subject must pick up a pin with the tweezer, place it in the appropriate hole, and place a collar over it, flange down; then repeat until all pins and collars are placed. He then picks up a screw with his fingers, places it in the appropriate hole to the right, turns it until the threads are engaged, screws it down with a screw driver, and repeats until all screws are placed. (Photo courtesy of The Psychological Corporation.)

in a group of occupations, seems to be important, then he may try out one of the available occupational interest questionnaires. And if the individual's past experience, his social obligations, and similar biographical data appear to be important, then the psychologist may try out biographical inventories already available. He also may have to devise tests that are entirely new.

After tests have been selected from those available, or special tests have been devised, the next move is to try them out and see how well they work in practice.

Development of a standardized procedure for administration and scoring. We have already (pp. 514–515) shown how important it is that psychological tests be given and scored in the same way for every individual tested. Anyone who uses a micrometer in a novel fashion or who reads off the measurement in some manner of his own choosing might just as well not use an accurate measuring device at all. Not only would his own readings differ from time to time, but they would certainly not agree with those taken by somebody who knows how to use a micrometer. Likewise, in the attempt to measure anything, a standardized procedure must be used. Usually, in preparing any sort of psychological test, it is necessary to try it out on a few individuals to see the best procedure to follow, how best to score it, and so on. If it is a pencil-and-paper test, requiring answers to questions, one has to do some preliminary testing with it to weed out ambiguous questions and questions that are obviously too difficult or otherwise unsuitable.

Administration to a large representative group. Because a test seems to measure the processes which a job analysis suggests are important for a particular job, and because it is standardized in administration and scoring, one cannot assume that it is necessarily a good test. One must check to see whether it really does select the kinds of individuals needed.

During the First World War some psychologists decided, on the basis of a crude job analysis, that a pilot needs, above all else, to be a quick reactor and to be able to "keep his head" under conditions of stress. So they and the military authorities of the countries concerned decided, quite arbitrarily, that any candidate for pilot training who failed to reach a specified speed of simple reaction, and who changed his breathing and his hand-tremor more than a certain amount when a shot was fired unexpectedly, or an ice-cold cloth slapped unexpectedly on his head, could not be a good prospect for pilot training. This proposition seemed so reasonable that several Allied countries used these tests to pre-select pilots. Hundreds of prospective pilots were told that their reactions were too slow or their emotional reactions

too unstable for them to succeed as pilots. Then some investigators checked up to see whether there was actually any correlation between simple reaction time and tremor on the one hand and skill as a pilot on the other. They found the correlations negligible. This being the case, as many good pilots were being eliminated as poor ones and as many poor ones were being selected as good ones. Those in charge of selecting pilot material would have been just as well off without using these reaction time or tremor tests.[8]

Tests must be evaluated by trying them out on a group representative of a particular occupation. There are several technical considerations in selection of this group, for it must be representative of a normal population, and so on — but we must waive this discussion in an introductory course.

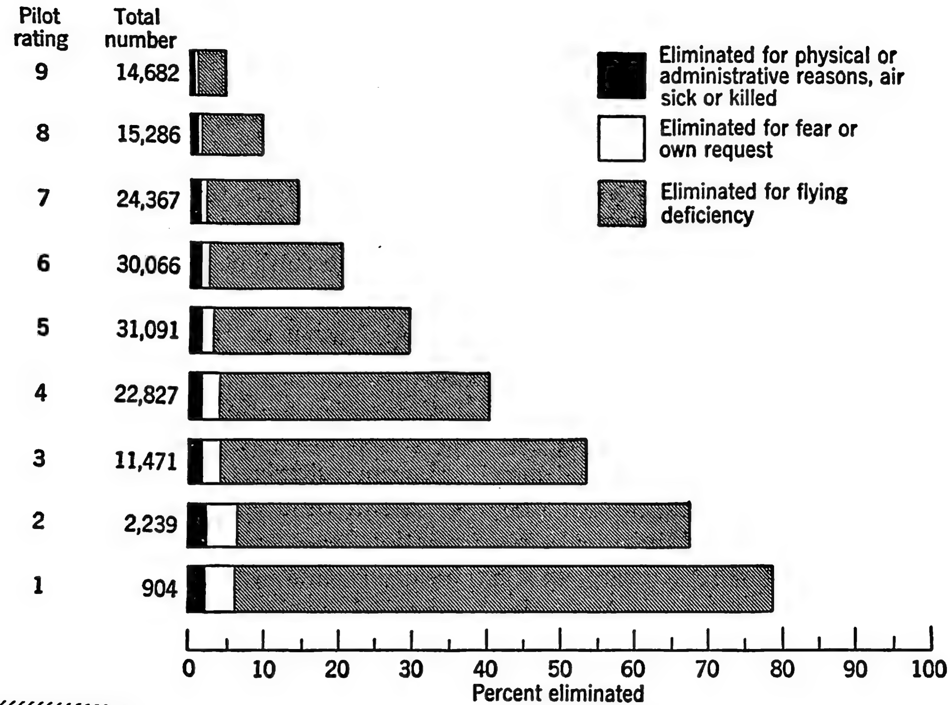
In devising selection tests for pilots, the psychologists in the Army Air Forces and Bureau of Aeronautics of the Navy Department gave their tentatively selected tests to thousands of prospective pilots and then allowed these individuals to enter training, regardless of scores made on the tests. In this way they could determine what would have happened had they eliminated those scoring below certain possible critical scores. Likewise, those who devised the medical aptitude tests used to select medical school students, at first gave the tests to students whom they allowed to continue into medical school, regardless of the outcome.

Evaluation of test results. To evaluate test results in terms of actual performance in an occupation, one must have criteria of success. In the case of pilots, the criteria might be ground-school grades, time taken to reach the solo, passing or failing, success in combat — number of planes shot down, and so on. Where medical students are concerned, the criterion might be the average medical school grade, passing or failing, rating given the individual by his medical school teachers, or rating as an interne. In the case of workers in a certain occupation, the criterion might be how quickly the requisite skills are learned, the average daily output, how many accidents the individual has, or how long he stays on the job before being fired or quitting to get another job. In the case of life insurance salesmen, the criterion might be how much insurance is sold. One must decide beforehand, of course, which of these things he wishes to predict by use of his test. The test might predict one criterion better than another. Different test batteries might be needed for different criteria.

One method widely used to determine the relation between the test results and the criterion is that of correlating one with the other. A high positive correlation indicates that success on the test and success in terms of the criterion selected go together. The correlation between scores on the medical aptitude tests and grades made in medical school is approximately .60. This suggests that the test is highly useful in selecting a *group* most of whom will make high grades. If it were 1.00, we could also safely select individuals with it. In other words, we could predict with practical certainty that the individual who made the highest score on the test would make the highest grade in medical school and that the individual who made the lowest grade on the test would make the lowest grade in medical school. The lower the correlation, the less likely we are to be correct in making predictions about what individuals will do (see p. 504).

One criterion in which those who had to select pilots were particularly interested was that of passing and failing the course. Anybody who entered training and failed to become a pilot was, of course, wasting his own time, wasting the time of his instructors, wasting government money, and wasting equipment. There was thus a determined effort to eliminate such waste by selecting a group most of whom would pass.

When such an arbitrary all-or-none cri-



281

Per Cent Eliminated from Primary Pilot Training

This includes those eliminated for flying deficiency, fear or at own request, and for physical or administrative reasons. It covers each pilot rating in fifteen consecutive pilot classes totaling 153,000 cases. The overall elimination rate was approximately 25%. (From Staff, Psychological Section, "Psychological Activities in the Training Command, Army Air Forces." Psychol. Bull., *1945, 42, p. 46.)*

terion as pass-fail is used, the usual correlation techniques discussed earlier will not work. Other techniques must be used. Nevertheless, we can illustrate the selective value of the tests by graphical means. In Figure 281 we have the pass-fail data for approximately 153,000 young men who took a battery of selection tests and then entered pilot training.[9] The battery of tests included several like those already discussed in preceding pages and another to be mentioned shortly.

The candidates' aptitude rating, in terms of test scores, is given at the left side of the graph. The highest aptitude rating is 9, and the lowest is 1. About 80 per cent of those who made the lowest aptitude rating failed. Less than 5 per cent of those who made the highest aptitude rating were eliminated. Without exception, the successively higher aptitude ratings had a decreasing number of eliminations for flying deficiency. It is obvious, without any detailed statistical analysis, therefore, that this is a good battery of tests for selecting those who will probably pass the pilot training course.

One test in the battery was almost as good as the whole battery. This, the School of Aviation Medicine's *Complex Co-ordinator,* was one of the few tests devised especially for selection of pilots. It is illustrated in Figure 282.

The apparatus is in part a simulated cockpit with rudder bar and stick. The in-

dividual being tested sits with his hand grasping the stick and his feet on the rudder bar. The panel before him has parallel sets of bulbs. The three groups of 13 pairs each are used in the test. In one row of each pair is a red light which stays fixed when the lights come on. As the stick is moved from the central position to the left, green bulbs light up successively to the left in the lower top row. As it is moved to the right, they light up successively to the right. The candidate's job is to match a green light with the red, so that one appears directly below the other. Likewise, by moving the stick forward or pulling it back, he controls the lighting of green bulbs in the central column, and must get a green light opposite the red one. Likewise, the rudder bar is manipulated with the right and left foot to match red and green lights in the bottom group. As soon as all three red lights are matched with green ones by appropriate manipulation of stick and rudder bar, the red lights shift to new positions. Then the procedure just described is repeated. This continues until 40 settings of three red lights each have been matched. Motor dexterity, speed of reaction, and several other processes are tested simultaneously by this device.

282

The S.A.M. Complex Co-ordinator

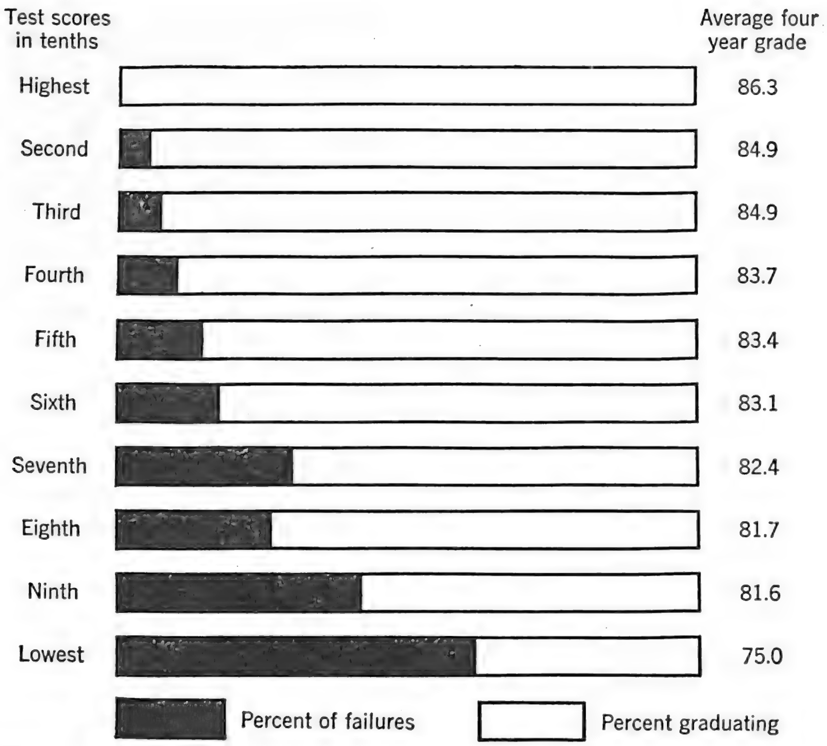
A red light goes on in each of the three sets (upper, lower and central) and, by appropriate manipulations of the stick and rudder bar, the testee must light the green bulbs opposite the red ones. (Air Force Photo.)

Of those who made the aptitude rating of 9 on the S.A.M. Complex Co-ordinator, 11 per cent failed the course. But of those who made the lowest aptitude rating, over 70 per cent failed.

A further illustration of the value of aptitude tests is given by the data in Figure 283. Medical aptitude ratings of students who were allowed to enter medical school are shown in tenths (deciles). Average grades and the per cent of each group which failed to graduate from medical school are also shown. Generally speaking, the grades increased as the aptitude scores increased. We have already mentioned that the correlation between test scores and average four-year grade in medical school is around .60. It is apparent, too, that all who made the highest aptitude rating graduated, and that the lower the aptitude rating, the greater the percentage of failures. Of those rating in the lowest tenth, over 50 per cent failed to graduate.

Medical course graduates were also rated as internes. Of those in the highest aptitude group, 41 per cent received the highest rating as an interne. On the other hand, of those who made the lowest aptitude rating, only 10 per cent received the highest rating as an interne. While none of those with the highest aptitude rating rated as low as 4 or 5 as an interne, 37 per cent of those with the lowest aptitude rating rated this low as internes.[10]

The experimental and evaluation procedures discussed in the preceding pages are actually validation procedures. A valid test is, as we have already suggested (p. 500),



283

The Relation Between Medical Aptitude Rating and Success in Medical School

One can see that there is, in general, an increasing likelihood of success in medical school as aptitude scores increase. The average four-year medical grade also tends to be higher the higher the aptitude score. (After Moss.)

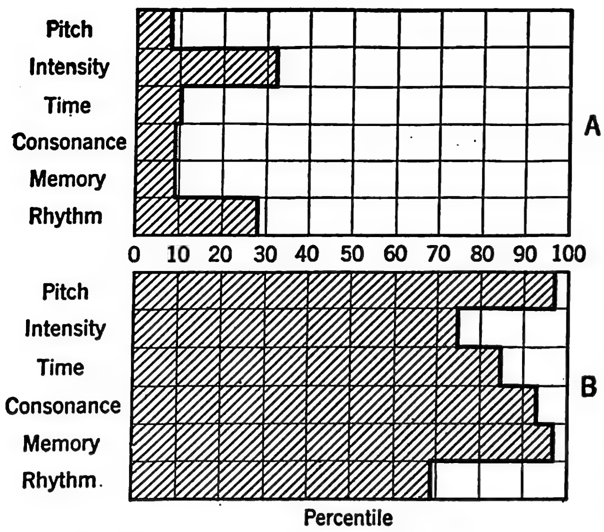
one which actually tests what it is designed to test. The tests selected for illustration are valid tests because they do differentiate the successful and the unsuccessful in the occupations involved. If they failed to differentiate significantly, they would not be used in actual selection. As a matter of fact, many of the tests which look good — which have "face validity" — turn out to be of little or no use when they are evaluated. We have already given, as an example of this, the simple reaction-time and tremor tests used to select pilots in the First World War.

MUSICAL APTITUDES

Musical aptitude tests, of which there are now several, are on phonograph disks. The subject sits, listens, and attempts to discriminate. In taking the Seashore Tests of Musical Talent, for example, he is tested for pitch discrimination, intensity discrimination, discrimination of rhythm, discrimination of timbre, time discrimination, and tonal memory. Instructions for the pitch discrimination tests are as follows:[11]

> You will hear two tones which differ in pitch. You are to judge whether the second is higher or lower than the first. If the second is higher, record H; if lower, record L.

The individual then listens and reacts to pairs of tones, the second tone of each pair following the first by a very short interval. Other tests in the series are per-



284 **A Portion of the Musical Talent Profiles of Two Individuals Differing Markedly in Musical Ability**

A *is an unmusical person. One sees that his percentiles for various items in the test are all below average. He is in about the 7th percentile for pitch discrimination, the 31st percentile for intensity discrimination, the 10th percentile for sense of time, and so on.* B, *the musically talented man, on the other hand, is well above the average in everything. His pitch discrimination score, for example, is in the 97th percentile. (Data in Seashore, C. E.,* The Psychology of Musical Talent. *New York: Silver, Burdett, pp. 23 and 25.)*

formed in a fashion somewhat similar to that described.

Actual scores on each test are translated into percentile scores. As one may recall from our earlier discussion of percentiles, the individual with a percentile score of 90 is equaled or exceeded by only 10 per cent of those tested when the test was standardized. A person with a percentile score of 1 is equaled or exceeded by 99 per cent of those tested. An idea of how the test differentiates extremes of musical talent is given by the musical talent profiles in Figure 284.

It is conceivable that a person might score high on such a test as the above, yet, because of poor finger dexterity, make a poor pianist or violinist. No matter what his dexterity, however, he could hardly hope to be successful in any aspect of musical performance without at least reasonably good pitch, intensity, and time discrimination.

The Seashore Test of Musical Talent and others of its kind are widely used in school systems to help in selecting the most musically gifted. A teacher of psychology who gives the test to his classes sometimes comes across a student who, although he has never had any musical training, scores exceptionally high on the test. In schools which use musical aptitude tests, such individuals may be discovered early and encouraged to take up some musical pursuit. On the other hand, those children who have little aptitude for music can be discouraged from attempting to become highly proficient musical performers.

VOCATIONAL GUIDANCE AND SELECTION

How are test results actually used in guidance and selection? Several hints have already been given, but this is a good place to discuss guidance and selection more directly.

When an individual comes to the vocational counselor for guidance concerning a vocation, he may be given one or a number of the tests mentioned in this chapter, or other tests not mentioned here. After comparing his score with that of others on whom the tests have been validated, the vocational counselor may then be able to offer such advice as: "You have sufficiently high intelligence to do well in any of these fields, but this is the field that seems to interest you most. It is a field which requires a high degree of mechanical aptitude and the test shows that you are not handicapped there. The chances are that, if you apply yourself, you will succeed in that field." On the other hand, he might have to say, "Your responses on some of these tests (intelligence) do not offer much hope of your being successful in getting an M.D. degree, but these other

tests (mechanical aptitude) show that you have exceptional ability along mechanical lines, that you have a high probability of success in some industry where mechanical talent like yours is required." There are, of course, some who have little aptitude for anything, and others who have aptitude for a wide variety of vocations.

The vocational counselor does not tell an individual that he will or will not succeed in a given line of work. There are many other things which contribute to success or failure in any line of work besides those measured by tests. The availability of training and of work in various occupations also has to be considered. Sometimes there are very few jobs available along the line of one's predominant aptitudes. What the vocational counselor attempts to do, however, is to deal with possibilities and probabilities as they relate to the individual's tested aptitudes. Unless correlations between test results and actual performance are very high, any definite predictions about what individuals will do are precarious.

In the case of vocational selection, on the other hand, predictions can be made with greater certainty than in the case of individual guidance. The psychologist can say with a high degree of assurance, for example, that if individuals who fall in the lowest aptitude rating are admitted to flight training, only about 20 per cent of them will become pilots, and if those in the uppermost rating are admitted, over 90 per cent of them will become pilots. If John Doe's score alone is involved, one can say merely that he will probably pass, or fail, or that the chances are 90 in 100 that he will pass or 10 in 100 that he will fail. Observe that some in the lowest aptitude rating do succeed, and John Doe might be one of them. Observe, too, that some in the highest aptitude rating do fail, and John Doe might be one of these.

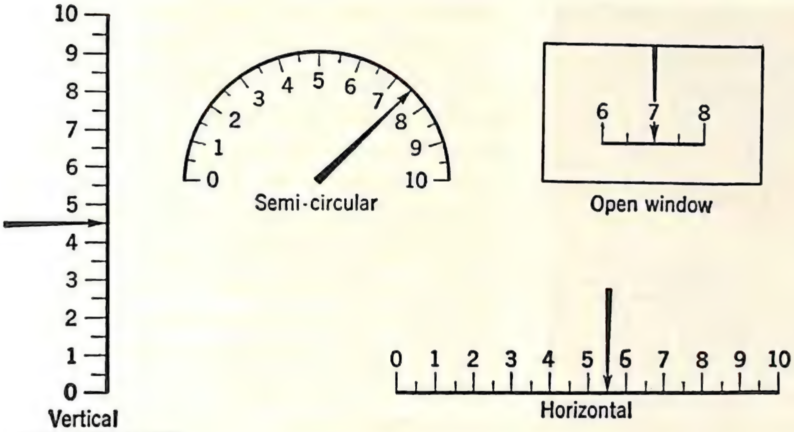
It is well to observe, finally, that even the best aptitude test used for selection purposes eliminates some individuals who, if admitted to the occupation in question, would have succeeded. We do not know who these people are unless we give everyone a chance, but if we do give everyone a chance we waste time, money, equipment, and manpower in attempting to train a group of whom many will fail. In order to avoid this wastage, we sacrifice a few who might have succeeded. What the user of selective tests does is to determine which critical score (the score below which individuals are not admitted to the occupation) will eliminate the greatest number of potential failures while at the same time eliminating as few as possible of the potentially successful.

How high the critical score may be set depends, too, upon how many individuals are needed and how many are available. Setting an aptitude rating of 9 as the standard for admittance to pilot training would eliminate all failures but a few, but very few individuals make an aptitude rating of 9. If only a few pilots were needed and the source of supply were large, such a rating might serve one's purposes. But if the number of pilots needed were high and there were only a limited number of candidates, one would have to lower his standard to a level where a sufficiently large number could be admitted.

HUMAN APTITUDES AND ENGINEERING DESIGN

So far we have stressed the problem of getting individuals for the job, or of finding jobs for which particular persons are best fitted. Here we consider the fact that equipment can be designed to fit human aptitudes, thus increasing the efficiency of performance.

Engineers often design equipment for appearance, convenience, or physical efficiency without recognizing that the persons who must operate it are limited in their perceptual and motor aptitudes and capacities.



285

Five Dial Shapes

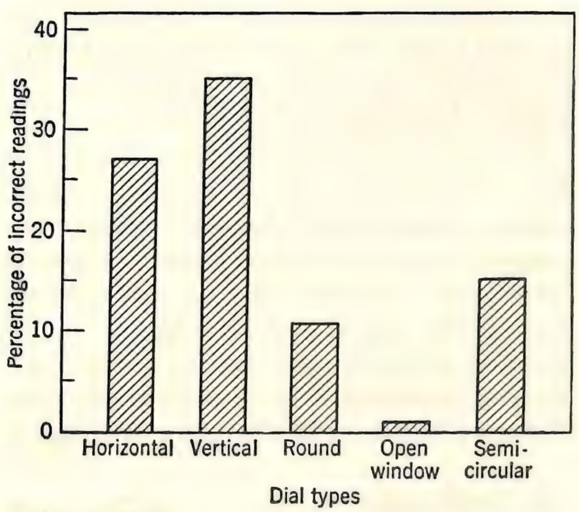
Note that the figures, the indicators, and the spacings are all alike. Problem: which dial can be read with least error? (After Sleight, "The Effect of Instrument Dial Shape on Legibility." J. Appl. Psych., *1948, 32, p. 177.)*

More specifically, engineers have often failed to determine which of the various possible designs human beings can operate most efficiently. Experimental psychology can obtain the relevant information.

As one example of experimental psychology in engineering design, take readability of dials. In Figure 285 are shown five dials, all with the same numbers, same pointers, and the same distances between numbers. Any one of these dial types might appear on a speedometer or altimeter. But which will be read with least error by the average person who must use it? Research involving a constant exposure time of .12 second demonstrated that the open-window dial is most and the vertical dial least accurately read. The results are presented graphically in Figure 286. Other things being equal, one would expect a person to read most accurately an open-window type of dial.[12]

There are many other problems in dial design, including the best spatial arrangement of particular dials in situations like the cockpit of the DC-6, pictured in Figure 287. Submarines, ships, and many industrial machines also have complicated controls. Research can discover the most foolproof arrangement of such controls.[13]

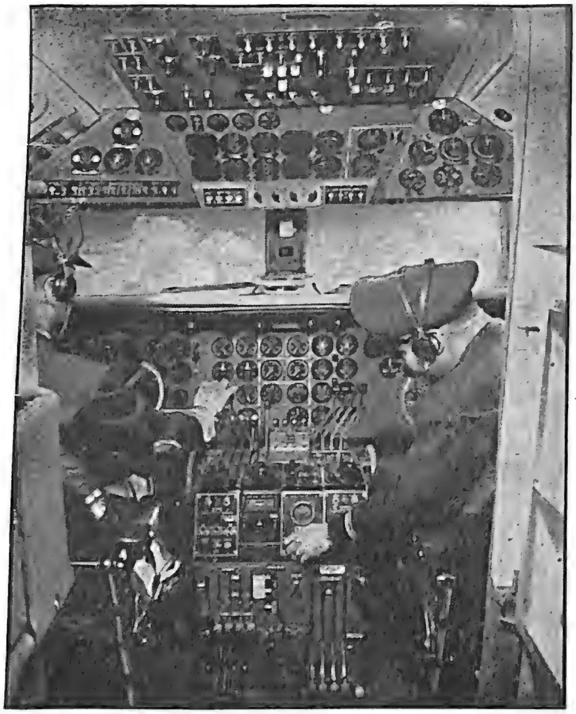
Another problem is the design of control knobs which will be confused as little as possible. One study carried out by psychol-



286

Per Cent of Error in Reading Dials

The dials are those pictured in Figure 285. (After Sleight, op. cit., *p. 182.)*



287

The Interior of a DC-6 Cockpit as the Pilot Views It

What is the best arrangement of such a complex array of instruments and controls? In other words, which of many possible arrangements will lead to least error? This is one of the many problems which confront the engineering psychologist. (Photo courtesy of American Airlines.)

ogists working for the Armed Services, compared the degree of confusion between twenty-two differently shaped knobs, which were distinguished purely by touch. Out of the twenty-two, eight were found which individuals never confused, one with the other. When operation of knobs in the dark, out of sight, or even within the field of vision is required, such knobs should be used.[14]

Still another problem in the field of adapting machines to human aptitudes is that of designing the equipment to be operated in such a manner as to speed the learning process and to achieve the highest possible level of work efficiency. A recent study focused upon operation of a hand wheel (crank), such as appears on many machines, including anti-aircraft equipment. The task was like that required by a pursuitmeter. Proper operation of the hand wheel kept a movable pointer in alignment with a stationary one. What the experimenter sought to discover was the most effective combination of such factors as speed of turning, gear-ratios, size of the hand wheel, and its weight. He found, among other things, that a heavy hand wheel, as compared with a light one, smooths and increases the accuracy of tracking.[15]

For a further example of engineering design to increase efficiency, the reader should again refer to the discussion on page 150. There we emphasized the optimal arrangement of work materials.

What psychologists in this field are attempting is to design equipment which takes fullest cognizance of human talents and weaknesses. As one writer says, "For many years playwrights have constructed plays to fit the specific talents of individual actors and actresses to bring out their best performance. So in the area of manipulative behavior, which is such an important factor in our modern civilization, it is possible to construct machines which will yield optimal results with a large number of workers."[16]

SUMMARY

Aptitudes are inferred from the differences with which individuals acquire proficiency in certain kinds of activity, and also from differences in the degree of proficiency. Most individuals have a high degree of aptitude for certain vocations and only a low degree for others. A few have aptitude for a narrow range of occupations, and a few

have aptitude for a wide range of vocations.

Aptitudes are not necessarily inborn, although some — like musical and mechanical aptitude — may depend to a certain extent upon inborn characteristics. Generally speaking, when we say that a person has a high degree of aptitude for a certain vocation, we are merely stating that, in terms of what he now is — regardless of the cause — it is highly probable that he will succeed in the vocation if given appropriate training.

General intelligence is related to some aptitudes (like aptitude for college work) more than to others. Moreover, many occupations require a minimal intelligence level. Interests are also related to aptitude. Those who succeed in certain occupations have a pattern of interests somewhat different from those of people who succeed in certain other occupations. For example, an individual with the same interest pattern as successful life insurance salesmen shows some bias in the direction of success in that occupation. Mechanical aptitude of one kind or another is required for many occupations, hence general tests of mechanical aptitude are given wide application.

Aptitude tests for use in guidance or selection with respect to specific jobs must be standardized and evaluated for the jobs in question. In general, the procedure followed is to make a job analysis, to tentatively select or devise tests which possibly measure psychological processes shown by the job analysis to be relevant, to develop a standardized administering and scoring procedure, to administer the test or test battery to a large group representing the group from which applicants are to be selected, and finally to evaluate the test in terms of how closely test scores are related to actual success in the occupation. In the latter instance, criteria of success must be available, such as passing or failing, or time to reach a specified level of proficiency. To the degree that scores on the test are positively related to variations in a criterion — to that degree the test provides a valid measure of success in terms of that criterion. Tests selected for illustrative purposes were the Army Air Corps Classification tests, used in selecting pilots, and the medical aptitude tests, used to select medical school students.

Musical aptitude tests measure musical aptitude in the most general sense. For special musical skills, like piano playing, more specific aptitudes are also required.

A certain aptitude rating has different predictive possibilities in the cases of individual guidance and selection of groups. We might be justified merely in saying that John Doe will probably succeed or fail in a particular occupation. On the other hand, we might be justified in saying, of a group with the same rating, that about 80 per cent will in all probability succeed, and 20 per cent in all probability fail. In setting a critical score and eliminating all those who make a lower score, we eliminate some individuals who might succeed if they were given a chance. What the psychologist tries to do is to eliminate as many potential failures as possible, and at the same time eliminate the smallest possible number of those who might succeed.

Psychologists are now turning their attention to the design of equipment so that human aptitudes can be more fully utilized, thus increasing the accuracy and efficiency of work.

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24 PERSONALITY

Personality Defined: Traits; the search for primary traits • Methods of Investigating Personality: Case history; rating; pencil-and-paper personality measuring devices; behavior tests; interviews; free association and dream analysis; projective methods • The Origins and Growth of Personality • The Biological Influence: Secretions from the endocrine glands; physique and temperament; the neural influence • The Situational Influence: Beginnings of response to social situations; home influences; the only child; other social situations • Normal and Abnormal Personality: The psychoneuroses; the psychoses • Summary

In turning to the study of personality we are putting together much of what has already been considered in this book. So far we have looked at individuals from this angle and that, usually with emphasis on what is more or less characteristic of human beings — not of Tom Smith or Mary Brown. Now the focus is on particular individuals, for no two persons have the same personality.

The principles underlying development of your personality and mine may have been the same, but the end product is different. Likewise, the methods of testing our personalities may be the same, but what these tests reveal is, of course, also different.

Personality is, in a sense, the completed jigsaw puzzle — the whole individual considered as a whole. Our statement is qualified with the words "in a sense" because personality is not a mere juxtaposition of parts or segments — it is an integration, a blend, a merger, an organized whole in which particular functions, unless we attend to them separately for purposes of analysis, lose their identity within the total pattern.

PERSONALITY DEFINED

Personality may be defined as *the most characteristic integration of an individual's structures, modes of behavior, interests, attitudes, capacities, abilities and aptitudes.* We say "characteristic integration" for two reasons. In the first place, you are characterized, or distinguished from others, by your personality. In the second place, only those aspects of you and your behavior which we regard as more or less permanent — as characteristic of you — are embraced by the term *personality.* If you are usually calm in situations of stress, but happen to "blow up" once or twice in a long while, the calmness rather than the irritability is regarded as part of your personality. Calmness is characteristic of you, while emotionality is not characteristic.

Although personality is the characteristic integration of every aspect of the individual, some aspects give more weight to the total product than others do. Your sensory and perceptual processes, your ability to learn, your ability to remember and to reason, and certain of your motor reactions are, as it were, pushed into the background by such aspects of behavior as how well you get along with other people, your susceptibility to irritation because of what others do and say, your manner of speech, the way you

dress, your motives, and the degree to which your behavior conforms to what other people regard as moral or good. The last-mentioned is the basis for speaking of your character, which is personality viewed from the standpoint of the ethical or the moral. Your most enduring characteristics which have social and ethical significance are often referred to as "character traits," to distinguish them from characteristics of no particular social or ethical significance. Honesty would thus be a "character trait," and your speed of reaction a "personality trait," not further differentiated as in the case of honesty.

Your physical appearance is also important — whether you are large or small, handsome or ugly, fat or thin, tidy or untidy. This is important in a rather peculiar way. It determines to a large degree how others react to you — which in turn also determines how you react to them. If they avoid you or cause you to suffer indignities because of your appearance or behavior, you may respond by becoming aggressive, or you may "crawl into your shell" and live in a world of fantasy where you are all that you would like to be. If they lionize you — if you find yourself the "cock of the walk" — you also respond accordingly. You may become conceited, domineering, or merely patronizing. It is not your physique as such which is important, but how people react to it. In certain regions of Europe a goiter is a sign of beauty; in central Africa, a protruding abdomen is a sign of beauty; and masculine-looking women are preferred in some societies.

The aspect of the personality picture that predominates is always the social aspect. Those who say, quite incorrectly of course, that someone "has no personality" are saying, in reality, that they do not like him, or that they are indifferent to him. When they say, on the other hand, that someone "sure has a personality!" they are actually saying that they like him — that they are attracted

288

Some Persona of Classical Times

Masks like these were worn to show what role an actor or actress played. They were made necessary by the fact that a large audience could not see the person's face with sufficient clarity. These masks were used in Greek comedies to represent (left and center) slaves, and (right) a courtesan. (From Bieber, M., The History of the Greek and Roman Theater. *Princeton: Princeton University Press, 1939. Photos courtesy of Dr. Bieber.)*

to him rather than repelled or left indifferent. Popular terms like "it" and "sex appeal" further illustrate the point that, whatever your personality may be in cold abstract scientific terms, to others it means your social self. Indeed, the term *personality* was probably derived from the name of the mask (*persona*) which actors once wore to indicate to the audience whether they played the villain's or the hero's role in a drama (Figure 288).

Traits

Although we are dealing with the person as a whole when we consider his personality, we need descriptive terms more discriminating than the over-all term *personality*. We look at the individual in different ways, from different angles, or in different lights, and we need terms to represent these different facets or, as they have been so aptly called, "dimensions" of personality. We speak of these dimensions as *traits*.[1] Some sample personality traits are intelligence, aptitude, emotionality, introversion, dominance, pugnacity, vivacity, and sociability. Most of our personality tests are designed to measure such traits rather than the entire personality.

The search for primary traits

How many different traits are there? Around eighteen thousand trait names have been located in dictionaries, but many are different names for the same thing.[2] Even personality tests devised to measure different traits sometimes correlate so highly with each other that it is apparent that they are measuring the same trait under different names.

Factor analysts are working with a large variety of personality tests in an effort to "factor out" primary traits; that is, the smallest number of traits which, taken together, give an over-all assessment of a personality. The most comprehensive of these studies has revealed twelve apparently irreducible traits. Some of these are named in the technical terminology of psychiatry, but among others are intelligence, dominance, emotional maturity, sensitive anxious emotionality, and the cultured mind.[3] A more recent study by another investigator has revealed only seven traits, few of which are identical with those which appear in the list of twelve.[4] It is apparently too early in the game to present a definitive list of traits, but we may look to the day when the writer of a textbook like this can say, "These are the primary personality traits and here are the tests which provide a measure of each."

The tests and questionnaires described in the following pages are like many which factor analysts have studied in their search for primary traits. These are criticized by many as dealing only with "surface" traits — with the "mask" that the "player" presents to his audience. The "depth psychologists" feel that deeper lying traits, those "imbedded deep in the person" are of even greater significance than surface traits. These "depth" aspects of personality have been emphasized by psychoanalysts and by some of the investigators who use projective methods, discussed later in this chapter. As one psychologist has said, "The aim of experimental depth psychology is to arrive at the center of the personality where many different reactions exhibit the same common denominator."[5] The "depth" factors most frequently mentioned are inner strivings and aspirations — in a word, motives. Whether these can be inferred from personality tests or whether their study requires special approaches like those of psychoanalysis is a debatable issue which need not concern us here.

Personality, of course, changes with age. It changes rapidly during the early years of life, and then more slowly, and less markedly, as we grow from adulthood into middle and old age. Some aspects of its growth will be considered after we have described methods of investigating personality.

In addition to showing how personality is studied, our discussion of methods further amplifies the definition of personality and of personality traits already given.

METHODS OF INVESTIGATING PERSONALITY

Although it is possible to classify these methods in various ways, the following will do for our purposes: (1) case history; (2) rating; (3) pencil-and-paper personality measuring devices; (4) behavior tests; (5) interviews; (6) free association and dream analysis; and (7) projective procedures.

Case history

The aim of the case-history approach is to gather relevant data about the individual's ancestry, his home environment, his relations with his parents, his friendships, his illnesses, his sexual experiences, his educational history, his vocational history, and, in short, anything which offers hope of throwing light on his personality. Gathering such case histories requires special training. Many schools of social work offer courses in psychiatric case work. A case history was cited earlier (pp. 35–36) in this book.

Rating

We have put this method early in the list because it is often used with infants as well as adults. Infants may be rated as underactive, normally active, or overactive; as non-co-operative, normally co-operative, or exceptionally co-operative; as having or not having temper tantrums; as thumbsuckers or non-thumbsuckers, and so on. One well-known scale for rating child behavior lists a series of items and, after each, the following seven possible ratings: trait absent, very slight, slight, average, marked, very marked, extreme. It then requires the observer to rate her own judgment as: doubtful, fairly certain, or very certain. Some of the items rated on the seven-point scale are: Does he tease other children? Is he noisy in eating? Does he climb for objects? Has he good looks? [6]

Rating scales have been developed for use in studying many personality traits in adults. Here are some samples.

Emotional Maturity [7]

S (subject) chooses his course of action with reference to his own maximum satisfaction .... ____

S passes rapidly from one interest or attachment to another .... ____

S is conscience-ridden, anxious lest he violate the sanctioned codes .... ____

On this rating scale, which includes sixty items like the above, the individual may regard himself as S, checking the items which characterize him, or rate some S with whom he is acquainted. Norms obtained with a standardization group are given and the composite rating is compared with these.

The following might be used to rate a friend or acquaintance for appearance, manner, and a number of other traits.

Appearance and Manner [8]

Sought by others ____	Well-liked by others ____	Unnoticed by others ____
Tolerated by others ____	Avoided by others ____	No opportunity to observe ____

There are also check lists prepared for rating individuals on their commendable habits and on improvable aspects of personality.

Survey of Outstanding Traits [9]

Commendable	*Improvable*
Has very good health	Bad breath
Is enthusiastic	Use less cosmetics
Listens attentively	Use less profanity
Controls temper well	Attend more social affairs
etc.	etc.

Sometimes individuals are ranked rather

than merely rated in regard to the trait. By this means a group of sorority sisters or fraternity brothers might be ranked for the trait sociability, by giving the most sociable a rank of 1, the next a rank of 2, and so on, down to the least sociable. Other traits might be ranked in a similar fashion. Each person is then rated, as it were, in terms of where he stands with respect to the particular trait in the group to which he belongs.

Pencil-and-paper personality measuring devices

Following the pattern of test standardization already described in the two preceding chapters, psychologists have developed a large number of so-called personality "tests," in each case validating the test against some other index of the trait to be measured.

The pencil-and-paper tests are so designated because the subject answers various questions or indicates certain alternatives by marking the test form with a pencil. Many of these "tests" are merely questionnaires, check lists, and inventories. For purposes of convenience, we shall refer to all of them as "tests." The following excerpts from some of the better-known personality tests will indicate their general nature and suggest a few of the outstanding personality traits measured by pencil-and-paper devices. Each test is scored with a standard key, and individual scores are interpreted in terms of group norms. Percentile scores are usually given.

One widely used personality test is the George Washington test of so-called "Social Intelligence."[10] Social intelligence is defined simply as "ability to get along with others." Scores on the test as a whole are generally high for those who are popular and well adjusted in social situations. The revised form of the test has five parts, each measuring a different aspect of social life.* These are: judgment in social situations, recognition of the mental state of the speaker, observation of human behavior, memory for names and faces, and sense of humor. The part of the test having to do with memory for names and faces is very much like the recognition test given on page 212, where, as you will recall, you saw twelve faces and were later required to recognize them in a larger group. In the Social Intelligence Test, twelve names are also given, one with each face, and the testee is to indicate which of the faces in the larger group (presented a half-hour or so after the first group) goes with each of the given names. Sample items from other parts of the test are given below.

Judgment in Social Situations

A young man invites a young lady to go to a show with him. On approaching the theater he discovers he has left his pocketbook at home. It would be best to:

—— Try to get tickets on credit by offering to leave his watch as security.

—— Try to find some friend from whom he can borrow money.

—— Decide with her on a course of action.

—— Find some plausible excuse and go home to get his money.

Recognition of the Mental State of the Speaker

Eighteen different terms, like ambition, disappointment, admiration, love, envy, suspicion, and so on, are given and numbered from 1 to 18. The person taking the test is to put in the parentheses the number which represents the mental state of the person making the statement.

( ) There is something in the way he deals that makes me want to cut the cards.

( ) And to think that I had looked forward to this party for days!

* This test has been criticized on the ground that it is too heavily "loaded with abstract intelligence." Correlations with general intelligence tests have ranged from .25 to .75. For a critical evaluation, see Thorndike, R. L., and S. Stein, "An Evaluation of Attempts to Measure Social Intelligence," *Psych. Bull.*, 1937, 34, pp. 275–285.

Observation of Human Behavior

If the statement is true, encircle the T; if it is false, encircle the F.

T F A good way to keep on friendly terms with two people who are enemies is to attempt to reconcile them.

T F The majority of people appreciate a candid criticism of their faults.

Sense of Humor

The subject is to indicate for a number of items like the following (but not all as obvious) which alternative makes the best joke.

"Johnny, if you eat more cake you'll burst." (1) "Why, I've eaten this much before." (2) "No, I have a tough stomach." (3) "Then, I'll be able to take still more." (4) "Well, pass me some and get out of the way."

Another widely used personality test is the Allport A–S Reaction Study, which is designed to measure ascendency-submission.[11] There are two forms, one for men and one for women. Each form has a large number of items like the following.

In general, are your most intimate friends

younger than yourself ——
older than yourself ——
about the same age ——

At a stupid party something must be done to inject some life. You have an idea. Do you take the initiative in carrying it out?

invariably ——
occasionally ——
never ——

The Pressey X–O Test is used to get an index of emotionality.[12] One part of the test has groups of words like: suck, meanness, eat, ugly, and black. Any unpleasant word is crossed out by the subject. The subject then goes back to each group and, without changing his former marking, encircles the least pleasant word. In another part of the test a word appears in capital letters, for example, BATH, GIRL, DEATH, and so on. At the side of each capitalized word are five words in lowercase letters. Every word associated in the individual's mind with the capitalized word is to be crossed out. Here are two samples:

GIRL	health	figure	wrong	soft	climb
DOCTOR	scream	baby	head	sale	immoral

Then the individual goes through the list and encircles the one word that, in his opinion, is most closely associated with the word at the left. The third part of the test has groups of words in each of which the subject is to cross out everything he considers wrong. Here are two sample lists:

begging	swearing	smoking	flirting	spitting
dirt	idle	conceited	tough	smutty

After crossing out all the things he believes to be wrong, the subject then encircles the word representing the worst thing in each list. Other tests in the group are similar in nature to those described.

The Allport-Vernon Study of Values is in two parts.[13] The first part contains statements which the individual is to mark in terms of the alternatives given. Thus he says "yes" or "no" to the statement

> The main object of scientific research should be the discovery of pure truth rather than its practical applications.

In the second part of the test the subject indicates which of certain alternatives appeals to him most, which seems next most important, which seems next important to that, and which represents his least interest or preference. He is also called upon to respond to items like the following:

When you go to the theater do you, as a rule, enjoy most —

—— plays that treat the lives of great men

—— ballet or similar imaginative performance

—— plays with a theme of human suffering and love

—— problem plays that argue consistently for some point of view

This test is designed especially to discover the weight given by a person to things theoretical, economic, aesthetic, social, political, and religious. The person who gives a very high place to social things and a relatively low place to others is sometimes referred to as the "social man." According to the psychologist on whose work this study is based, there are six "types" of men, each of which gives the highest value to one of the spheres of life indicated above. A mixed type that balances the values is also recognized. Figure 289 shows a profile based upon this test.

One of the most widely recognized dimensions of personality is what everyone is familiar with as introversion-extraversion.* The introvert may be characterized briefly as "shut-in" and introspective; the extravert may be characterized as overtly expressive, "doing, more than thinking." Actually, as the introversion-extraversion tests have shown, there is a distribution of these traits closely approximating the normal frequency distribution, the extreme introvert at one end and the extreme extravert at the other, with most individuals, designated as ambiverts, near the center of the distribution. There are many tests of this general dimension. The following items from Root's Introversion-Extraversion Test illustrate both the nature of the test and the differentiation between introvert, ambivert, and extravert.[14] The first alternative is that most typically introvert, the middle one that most typically ambivert, and the last one that most typically extravert.

How do you like to be a leader at a social affair?

—— Do not want to be and avoid it

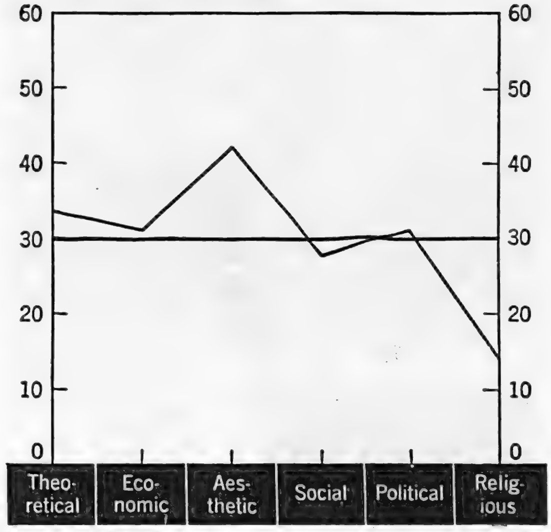
—— Prefer not being a leader

—— Never give the subject much thought

—— Would accept leadership at a social affair

—— Enjoy being a leader at a social affair

* The term *extroversion* is often used in place of *extraversion*.



289 **Profile Based upon the Allport-Vernon Study of Values**

The girl whose values are presented here is seen to rate highest on aesthetic values. Sometimes a person is equally high on several values. Scores from 0 to 20 are significantly low; from 28 to 31, average; and from 40 to 60, significantly high.

How do you prefer spending your odd moments?

—— Always spend odd moments reading and planning

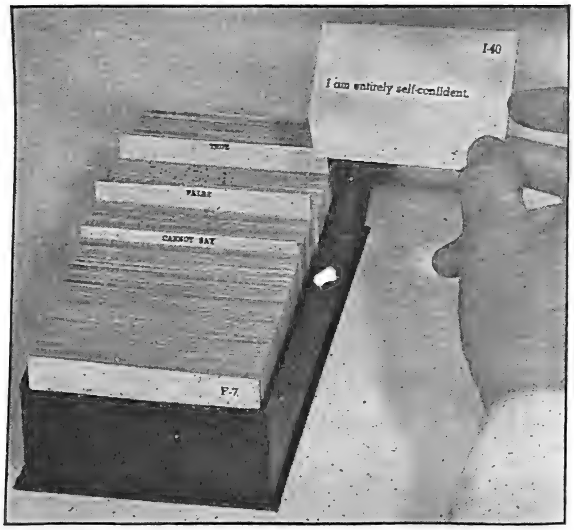
—— Prefer to spend odd moments reading and planning

—— Time equally divided between reading and physical activity

—— Prefer to spend odd moments in physical activity

—— Practically all odd moments spent in games and sports

As another example of pencil-and-paper personality tests, we shall take one based upon factor analysis of responses to a large number of personality tests. It is Guilford's Inventory of Factors STDCR.[15] The factors represented by these five letters are social introversion, thinking introversion, depression, cycloid tendencies (ups and downs of



290 **The Minnesota Multiphasic Personality Inventory**

Observe that there are three classification cards. These are, respectively, marked TRUE, FALSE, *and* CANNOT SAY. *Each of the other 550 cards has a statement relating to some aspect of personality. The subject is trying to decide whether the card with the statement "I am entirely self-confident" should be placed behind the* TRUE, FALSE, *or* CANNOT SAY *card.*

mood), and rhathymia (a happy-go-lucky disposition). Guilford says that these factors, "taken together, probably cover the area of personality generally encompassed by the concept of introversion-extraversion." It is pointed out, further, that "Each factor actually represents a dimension of personality with two opposite poles." The same answers are scored in five different ways to disclose the degree to which the five different factors are present. The following items are typical of the 175 items in the inventory:

Each item is to be responded to by encircling one of the three alternatives.

Do you express yourself more easily in speech than in writing? .... Yes ? No

Do you have frequent ups and downs in mood, either with or without apparent cause? .... Yes ? No

Are you sometimes so blue that life hardly seems worth living? .... Yes ? No

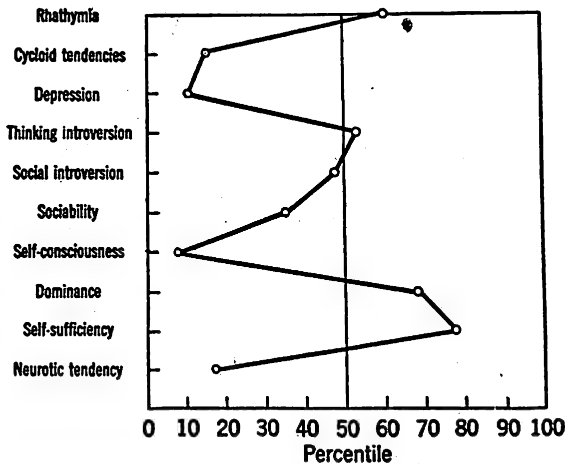
Do you like to play pranks upon others? .... Yes ? No

Are you frequently "lost in thought"? Yes ? No

Our final example is of a very widely used test which has two forms, individual and group, and certain features not present in the tests already discussed. This test, developed at the University of Minnesota, is known as the Minnesota Multiphasic Personality Inventory.[16] It has 550 items. The slant is decidedly psychiatric and scores are classified largely in terms of psychiatric categories. Thus are ascertained the person's leanings toward hysteria, mania, schizophrenia, and so on. When taking the individual form of the test, illustrated in Figure 290, a person is given 550 cards, each with a question. At the back of the box are three cards marked, respectively, TRUE, FALSE or CANNOT SAY. The subject is asked to read the statement and decide whether or not it applies to him. If it is true, or mostly true, he places it behind the TRUE card. If it is not usually true, or not at all true, as applied to him, he puts it behind the FALSE card. If the statement does not apply, or if it is something he does not know about, the subject puts it behind the CANNOT SAY card. Most of the items are very similar to those already cited from other tests. They deal with what a person characteristically does in certain situations, with bodily complaints, with fears, with feelings, and so on. Of particular interest, however, is the fact that this test includes a number of "traps" for those who, instead of answering honestly, try to make a good impression. Suppose, for example, that a statement reads: "I sometimes put off until tomorrow what I should do today." The person who is trying to make a good impression will place this, and others comparable with it, in the false group. But the person who is reacting honestly will al-

most certainly say that this is true—it is true of almost everybody. If the score for such items is above a certain level, the rest of the test is discounted, as yielding higher favorable scores than it should. High favorable scores on such items do, of course, reveal something about a person's desire to make a favorable impression. The number of CANNOT SAY items provides a check on carelessness in answering or on inability to understand the items. These and other checks are used to determine the validity of this inventory as applied to a particular person; in other words, to test whether it is actually revealing in a particular person the traits that it is designed to reveal.

The personality profile or psychograph. If a number of personality tests are given and the scores all put on a comparable basis, a personality profile or psychograph like that illustrated in Figure 291 may be drawn. This is drawn in terms of percentile scores. It enables us to see at a glance how the individual's performance compares with the central tendency (50th percentile) of the group on which the test was standardized. It also allows us to see at a glance his relative standing with respect to the various traits tested. Some individuals are consistently close to the central tendency, some are consistently above, and some consistently below. The separate traits of most subjects, however, vary between average and extreme positions like those of the subject whose personality profile is given. The tests used in obtaining these scores were the already mentioned Inventory of Factors STDCR and also Bernreuter's Personality Inventory.[17]



291

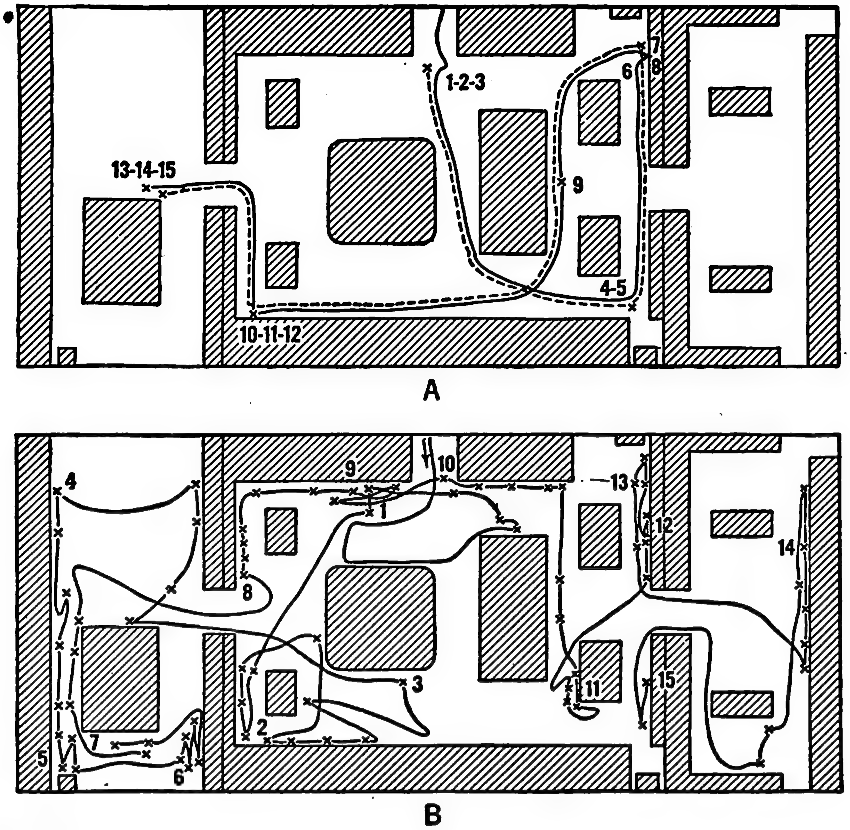
A Personality Profile

This subject equals or exceeds 60 per cent in rhathymia (happy-go-lucky disposition), equals or exceeds 15 per cent in cycloid tendencies (ups and downs of mood), equals or exceeds 10 per cent in depression, and so on. The 50th percentile represents the median score for the standardization group.

Behavior tests

In taking tests like most of those so far considered, the subject has to say what he usually does, what he thinks he would do, or what he thinks ought to be done in certain situations. The behavior tests are designed to discover what an individual actually does when confronted by particular situations. Thus, in a behavior test of introversion-extraversion for use with children, certain standard situations are presented and the tester records the reactions of the subject. Two examples will be given, one from an introversion-extraversion test and the other from a test of honesty.

Introversion-extraversion. Children were taken into a natural science museum the ground plan of which is shown in Figure 292. The path followed by each child was traced and the time that he spent at each exhibit was recorded as in the illustration. Slowness in moving from one exhibit to the other and poor attention to exhibits were taken as indications of introversion. The child who showed a great deal of spontaneous interest in the exhibits, who moved rapidly from one to the other, and went back to look at exhibits again, got a high rating for extraversion. Several other behavior tests were included in this study.[18]



292 **Different Behavior of an Introverted and an Extraverted Child in a Museum Situation**

A. *The path of an extremely introverted child. The child refused to move without the experimenter, whose path is represented by the broken line. Crosses indicate stops. Shaded areas represent exhibits. The figures show the subject's position at the end of each minute.* B. *The path through the museum of an extremely extraverted child. The long distances traveled and the stops are characteristic of the extravert. (From Marston, L. R., "An Experimental Study of Introversion and Extroversion,"* University of Iowa Studies: Studies in Child Welfare, *1925, vol. 3, no. 3, pp. 68 and 71.)*

Honesty. Each child was given a sheet of paper with ten circles, varying in size and position. The average and range of circles marked by blindfolded subjects were determined before the experiment proper began. In the test situation each child was asked to close his eyes and place a specified number in the center of as many circles as possible. He was given a trial with each of five sheets. The child then recorded as his score the number of circles marked. If a child had a higher score than the best that could be done by the blindfolded group, there was, of course, evidence of cheating. Several other tests of this general nature were used to measure honesty and also altruism.[19]

The chief difficulty with such behavior tests is that they are greatly limited in scope. They can, in the first place, only be used successfully with children. Adults readily "see through" them. Moreover, they deal with specific situations which may not be at all

representative of the many situations which an individual meets, each situation perhaps calling out a somewhat different reaction. Some people, for example, would not cheat their next-door neighbor for anything, yet would falsify their income-tax statement if they thought there was a good chance of "getting away with it." One cannot sample every situation that the individual meets and, since there is often much inconsistency between behavior in one situation and behavior in another, one cannot reliably characterize, on the basis of a few samples, the individual's personality, even with respect to a specified trait.[20]

Interviews

In business, industry, and medicine it is customary to estimate personality by having an interview with the individual.

The best interviews from the standpoint of the reliability of the results obtained are standardized. That is to say, the interviewer knows beforehand what questions he is going to ask and in what order he is going to ask them. This puts every person interviewed on a somewhat comparable footing as far as these aspects of the interview are concerned. Sometimes the interviewer uses a rating scale which enables him to estimate the degree to which the individual has particular traits. When the interviews are carried out for research purposes, as in a research on physique and temperament which we will consider later, the subject may be given a series of interviews and the ratings revised from time to time as the interviewer gathers new information. There have been a few instances in psychological research where the subject was rated separately by each member of a board of interviewers and the ratings then averaged. The chief difficulty with interviews is that so much depends upon the judgments of the interviewer. These cannot be standardized as scoring of tests is standardized.[21]

Interviews sometimes have therapeutic as well as informational objectives. In the so-called "nondirective" or "client-centered" interviews the client or patient not only reveals certain of his personality traits, but also, at times, gets insight into his own difficulties and how to solve them. This is called a "nondirective" interview because the psychologist does very little more than listen and direct the conversation to this or that point. He does not, in other words, give advice. The following excerpts from transcribed nondirective interviews typify such procedure: [22]

Excerpt from first interview

S (subject). Well, it's just reached the point where it becomes unbearable. I'd rather be dead than live as I am now.

C (counselor). You'd rather be dead than live as you are now? Can you tell me a little more about that?

S. Well, I hope. Of course we always live on hope.

C. Yes.

S. But — No, I don't have any conscious suicidal urge or anything like that. It's just that — looking at it rationally, I feel that I'm — that I'm in the red now and I wouldn't want to keep on living in the red. (Pause)

C. Well, can you tell me in any more detailed way what — in what way it blocks you so much that you really feel sometimes that you'd be better off dead?

S. Well, I don't know if I can any more accurately describe the sensation. It's just a — a very impressive and painful weight as if an axe were pressing on the whole abdomen, pressing down, I can almost — I can almost sense the position and I feel that it is oppressing me very radically, that is, that it goes right down to the roots of my dynamic energy, so that no matter in what field I assay any sort of effort, I find the blocking.

Excerpt from eighth and final interview

S. Well, I've been noticing something decidedly new. Rather than having fluctuations, I've

been noticing a very gradual steady improvement. It's just as if I had become more stabilized and my growth had been one of the hard way and the sure way rather than the wavering and fluctuating way.

C. M-hm.

S. I go into situations, and even though it's an effort, why I go ahead and make my progress, and I find that when you sort of seize the bull by the horns, as it were, why it isn't so bad as if you sort of deliberate and perhaps — well, think too long about it like I used to. I sort of say to myself, "Well, I know absolutely that avoiding the situation will leave me in the same old rut I've been taking," and I realize that I don't want to be in the same old rut, so I go ahead and go into the situation, and even when I have disappointments in the situation, I find that they don't bring me down as much as they used to.

C. That sounds like real progress.

S. And what pleases me is that my feelings are on an even keel, steadily improving, which gives me much more of a feeling of security than if I had fluctuations. You see, fluctuations lead you from the peaks to the valleys, and you can't get as much self-confidence as when you're having gradual improvement.

C. M-hm.

Free association and dream analysis

This, the typical psychoanalytical approach, has already been mentioned on various occasions. Like the interview techniques, it may be used as a means of gathering information about personality and also as a form of psychotherapy.

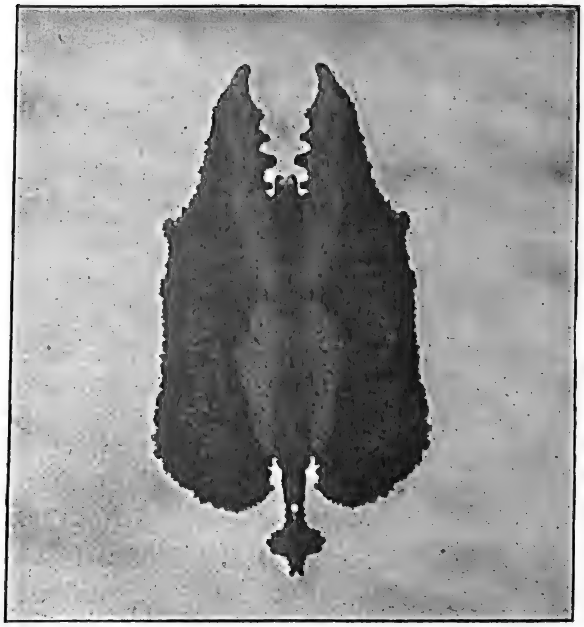
The patient reclines on a comfortable sofa and is encouraged to say everything which comes to mind, the analyst occasionally directing association by asking certain questions. The patient may reach a point where blocking occurs or where ideas seem too ridiculous, or too filthy, or too horrible for expression. Here the analyst urges the patient to express the ideas in question. Many such séances may eventually lay bare the significant aspects of the individual's life history. Sometimes, in the course of these séances, the individual breaks down emotionally — weeping, cursing, and so on. This emotional flareup is often found to have therapeutic value. In dream analysis the patient relates his dreams and these are analyzed for what they may reveal about his motives and other "depth" aspects of his personality.

Psychoanalytic techniques are more directive than nondirective. The analyst usually makes the interpretations and tells the subject what is wrong with him and what to do about it. These interpretations and the advice given are usually strongly colored by certain psychoanalytic theories which are regarded as highly questionable by many psychologists. From the standpoint of getting information about deep-lying personality traits, however, the psychoanalytic technique is often quite revealing.[23]

Projective methods

Several methods of studying personality fall within the projective classification. They are called "projective" because the individual "projects" himself, as it were, into the test situation. What he projects is believed to indicate certain "depth" factors in his personality.

Perhaps the best-known of the projective tests is that of Rorschach, which utilizes a group of ten standard ink blots.[24] An ink blot made in the same manner as those in the Rorschach Test is reproduced in Figure 293. Some of Rorschach's blots are, however, colored. The subject is shown the ten ink blots, one at a time, in a standardized order and position. He is asked, "What could that be?" or, "What do you see?" The subject is allowed to turn the blot and look at it from different positions. Different people, of course, "see" different things. Responses are scored in terms of the total number of items seen, whether the items involve the whole ink blot or only parts, qualities perceived (color, form, movement), and the



293 **An Ink Blot, and What Two Subjects Saw in It**

"It's obviously a pair of old witches facing each other. As to their complete form, they seem to be encased in a cocoon-like blanket fold."

"The skull of a bird. The open end is the beak, the rugged projections are the teeth. The projection from the rounded end resembles the handle of a knife. The dark line down the center is the blade. The skull seems flattened as though squeezed."

kinds of things reported (like anatomical parts, animals, plants, people, and so on). Some aspects of personality allegedly revealed by the response to the ink blots are suggested by these excerpts from the report of an expert Rorschach tester: "rich mentality," "illogical procedure and peculiarity of thinking," "ability to grasp relationships," "creative capacity," "breadth of interest," "relatively few emotional experiences that come to expression," "expresses special fantasies peculiar to his own need," "large amount of self-will," "resistiveness," "introversive personality." [25]

Scoring of Rorschach data is becoming fairly well standardized, but the interpretation of the scores is far from standard. Most Rorschach testers maintain that interpretation is necessarily subjective — that it calls for experience, ingenuity, insight, and common sense. According to an expert Rorschach tester, "Prolonged and extensive experience is necessary, not only with human personality but with all kinds of clinical problems. This last step, by definition, therefore, is personal to the examiner and subjective in him. It permits no norms, and it eludes all standardization." [26] Rorschach testers have reported considerable success in differentiating normal and psychotic individuals, and in distinguishing between different kinds of psychotics, in terms of Rorschach findings alone.[27] Nevertheless, many psychologists are skeptical of the enthusiastic claims often made by Rorschach testers. They want experimental evidence in support of such claims. Thurstone, for example, says:

> It would be fortunate if students of the Rorschach test would proceed to qualify themselves for membership in the psychological profession by insisting on experimental evidence under reasonably controlled conditions for the various interpretations that they make of the responses to a set of ink blots. There is justification for the belief that the projective test method of presenting to the subject an ambiguous task has great possibilities, and it seems plausible that a set of ink blots may be one of these fruitful test methods. [But] Rorschach students are not making any worthwhile contribution to psychological science as long as they remain in their gullible and uncritical acceptance of fanciful interpretations of the responses to a single set of ink blots.[28]

The Thematic Apperception Test [29] requires the subject to interpret each of a standard series of pictures, one of which is reproduced in Figure 294. Each individual interprets these pictures quite differently. His interpretation is analyzed to see what it reveals about his personality. Sometimes the idea of trouble, of suicide, of tragic love,

294

A Picture from the Thematic Apperception Test and Some Interpretations

The subject is shown the picture and asked to make up a story for which the picture may serve as an illustration. The tester says, "Tell me what events have led up to the present occurrence, what the character in the picture is thinking and feeling, and what the outcome will be." Here are four interpretations given by students in a beginning psychology course: "The girl appears to be nauseated. She may have eaten something disagreeable or she may have suffered a disappointment. At any rate, she is about to be sick." "The girl is distressed because she has to tell her mother something horrible she has done. Her mother is trusting up to this point, and the girl hates to disillusion her." "From the depths of poverty she has risen above the level of her common surroundings only to find that she is by social pressure forced back into poverty." "This woman has just been consumed with anger and, while in a fit of rage, has killed her husband. She suddenly comes back to her senses and realizes what she has done. Being a good woman at heart, she is stricken with remorse and decides to give herself up." (Reproduction of picture, courtesy of Dr. Henry Murray and the Harvard University Press.)

of death, and so on recurs again and again in the series of interpretations given by a subject. It is claimed that the subject, in responding to the Thematic Apperception Test, reveals some of his innermost fantasies without being aware that he is doing so. One investigator has used a test of this type to reveal adolescent fantasies.[30] The criticisms of the Thematic Apperception Test are basically those already mentioned in connection with the Rorschach Test. The interpretation of results has not yet been put on the quantitative basis which scientific procedure demands.

There are several other projective tests, but most of them follow the same general principle as the Rorschach and Thematic Apperception tests — in other words, the individual is called upon to interpret pictures, stories, or situations which lend themselves to a variety of interpretations. The interpretations are then reviewed by the tester to see what, in his opinion, they reveal about aspects of personality.[31]

All of the methods mentioned here — case history, rating, pencil-and-paper tests, behavior tests, interviews, free association and dream analysis, and projective techniques — have their place in the study of personality. Personality is so complex a phenomenon that any method which offers the possibility of throwing significant light upon any aspect of it is worth at least a trial. Quite often, as suggested earlier, psychologists who use psychoanalytic and projective techniques accuse those who use tests and rating scales of dealing merely with surface aspects of personality. Their own methods, they often claim, are getting under the surface — into the depths — of personality. Those who measure the so-called "surface traits," on the other hand, point out that psychoanalytic and projective methods are not so well standardized as personality tests, hence are less reli-

able than other personality measuring devices.

THE ORIGINS AND GROWTH OF PERSONALITY

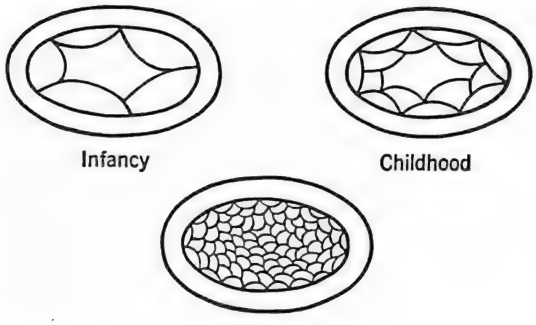
Differences in "looks" and in behavior are apparent at birth — one baby is judged good-looking, the other homely; one hardly emits a murmur, while the other squawks during almost every waking moment; one is active, kicking vigorously and thrashing his arms about, while the other lies relatively still; one sucks at the breast tenaciously, while the other sucks with seeming indifference. Although all babies may look alike and behave alike to anybody who observes them only superficially, to the one who observes them closely there are marked differences such as those we have just described — but are these personality traits? Some psychologists call them personality traits, but others say that they are not sufficiently stabilized to be regarded as consistent aspects of the individual.

Gordon Allport, one of our outstanding students of personality, stresses the view that only the relatively stable aspects of behavior are to be designated as personality traits. But he also believes that only those stable traits adopted by the individual as a means of adjustment should be regarded as aspects of personality. He says:

> From the evidence now in hand, four important conclusions may be drawn: (1) personality, defined as the distinctive mode of adjustment adopted by each individual in his efforts to live, is not formed at birth, but it may be said to begin at birth. (2) The earliest distinctive adjustments in respect to which infants can be said to differ are in the intensity and frequency of their spontaneous activity (motility) and in their emotional expression (temperament). Both these factors are primarily products of inheritance. (3) Probably not before the fourth month is there sufficient learning and maturation to form distinctive habits of adjustment or rudimentary traits; but by the second half of the first year adaptive responses to the physical environment and to people show marked distinctiveness. (4) Distinctive qualities noticed early in life tend to persist; the child seems predisposed to learn certain modes of adjustment and to reject others. Even before these adaptive forms are clearly defined an observer can often by the method of "prophecy" predict later traits. Irrespective of the methods used to study the consistency of early development the evidence is positive in virtually every case.[32]

The author goes on to say that he does not mean to imply that personality traits are definitely fixed in early childhood. Changes in social stimulation, illness, accidents, and many unpredictable situations may arise from time to time during early life and lead to markedly unpredictable changes in certain personality traits.

Although it is a legitimate question to ask whether a newborn baby has a personality (the answer, of course, depending to a large extent on how personality is defined), there is no question about the fact that infants have few distinguishable personality traits. The situation is somewhat similar to that dealt with in our discussion of emotion in infants, where we found only one emotion at birth, but an increasing number of emotions as a function of increasing age. In the case of personality, as suggested by the above quotation, the first personality traits to appear are few: motility, temperament, and perhaps a few habitual modes of behavior. As the child grows older, however, we find that such characterizations as dominant, persistent, sociable, selfish, introvert, bright, negativistic, sulky, and dozens of others are applicable with respect to his traits. In the adult there is almost no end to the trait terms which seem applicable. This suggests a gradual differentiation of the personality pattern. Some psychologists represent this differentiation as in Figure 295. Each of the regions within the whole figure, which stands for personality, represents a distinguishable personality trait.[33]



295 **Topological Representation of Personality Growth**

Think of the various areas as discernible personality traits. In infancy there are few, in childhood there are several more, and in adulthood there are many. (After Lewin.)

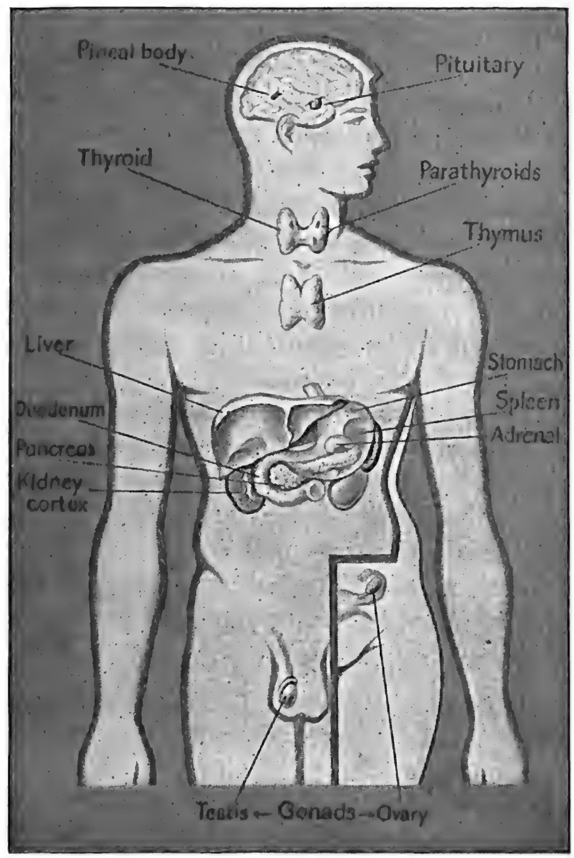
We may regard the development of personality as resulting from two general influences — the biological and the situational. Much of the consistency, or the persistent core, of personality from infancy to adulthood is attributable to our biological make-up. Some of the personal consistency, nevertheless, comes from the consistency of social situations — the culture in which we develop, what kind of parents we have and their characteristic way of treating us, our socio-economic status, our region or community. Later changes in personality are largely attributable to changes in our relations with parents, teachers and companions.

THE BIOLOGICAL INFLUENCE

Generally speaking, three biological influences are important in development of personality. These are: (1) *secretions from the endocrine glands,* shown in Figure 296; (2) *physique,* which is largely determined by glandular constitution, other inherited determiners, and nutritional level; and (3) *neural constitution.*

Secretions from the endocrine glands

As we have mentioned previously, the endocrine (ductless) glands pour their secretions (hormones) directly into the blood stream, which of course carries them to all parts of the body. We are, as one well-known endocrinologist has said, "terribly at the mercy of our endocrine glands." Unless endocrine secretions are poured into our blood stream in appropriate amounts, the whole bodily economy is disturbed and marked changes in appearance, physique, temperament, intelligence, and other aspects of personality may result. Each of these



296 **Approximate Location of the Endocrine Glands**

The pineal body, thymus, spleen and stomach have questionable status. Whether they give rise to internal secretions is not definitely known. (Redrawn from Turner, C. D., General Endocrinology. *Philadelphia: Saunders, 1949, p. 11.)*

changes may have social reverberations — leading us to repel rather than attract others, with resulting changes in our own social habits and attitudes.

It is well to know, at the outset of any discussion of endocrine functions, that the endocrines comprise what, in effect, is an interlocking system. Disturbing the function of one gland may lead to disturbances in the functions of other glands. Overactivity of the adrenal medulla, producing adrenalin in excess amounts, raises the blood-sugar level, thus counteracting insulin, the hormone from the Islands of Langerhans in the pancreas, which normally keeps the blood sugar at a constant level. Adrenal and pituitary disturbances influence functions of the sex glands (gonads). In Figure 297, for example, we have a six-year-old boy whose sexual development is that of an adolescent. Similar sexual precocity has been observed in females. It is often attributed to overactivity of the outer part of the adrenal gland (adrenal cortex) in early childhood. Pituitary disturbances also produce sexual abnormalities. Insufficient secretions from the pituitary may lead a male child to be fat and effeminate instead of normally developed sexually.

The interlocking nature of glandular functioning makes it difficult for endocrinologists to discover at all definitely the particular functions of certain glands. In some instances there is much difference of opinion among the authorities. Another thing that increases the difficulty is the fact that some glands secrete several different hormones. The pituitary gland is said to secrete at least eight hormones, the adrenal gland two, and the gonads of each sex at least two.

The chief functions of particular glands that are of special importance for personality may be summarized as follows: the *gonads* are responsible for sexual drive and secondary sex characteristics (in collaboration with the pituitary and adrenal glands). The *adrenal medulla* secretes adrenalin and thus influences emotional behavior. The *thyroid*

297 **A Boy with Puberty Praecox**

The child is shown between his brother of nine and his sister of eleven. His chronological age is six years and one month and his mental age six years. Sexual development is equivalent to that of an adolescent. (From McClure and Goldberg, 1932.)

secretion has an influence on vigor and temperament. Overactivity may produce "nervous tension" and underactivity may produce lethargy. Underactivity of the thyroid in early childhood is associated with cretinism — characterized by low intelligence and the physical appearance illustrated in Figure 298, A. Administration of thyroxin, the thyroid hormone, leads to normal development if it is given sufficiently early and continued throughout childhood. What a few months of such treatment can do is illustrated in Figure 298, B. Secretions from the *anterior pituitary* are largely responsible for general bodily growth as well as certain sexual functions. The giant that you see at the circus probably has an overactive anterior pitui-

298

Cretinism

The same child is shown as a cretin and again after four months of treatment with thyroxin. (From Nicholson, H. O., Archives of Pediatrics, *1900, vol. 17, pp. 433 and 436.)*

tary; the dwarf probably has an underactive anterior pituitary. There is no reliable evidence that the *posterior pituitary* has anything specific to do with personality. It appears to function chiefly in controlling certain metabolic processes. The glands that we have failed to mention by name have no functions of special importance from the standpoint of personality.[34]

It might be well to say a word of caution about endocrine functions. Although an underactive thyroid tends to produce lethargy, one must not jump to the conclusion that every lethargic person has an underactive thyroid. Nor should we conclude that any obviously nervous individual has an overactive thyroid. Likewise, even the most frigid person sexually as well as the most sexually driven may have normal gonads. In other words, while specific glandular malfunction may produce certain changes in personality, similar changes are often produced by other conditions — disturbance of other glands, malnutrition, and earlier conditioning.

Physique and temperament

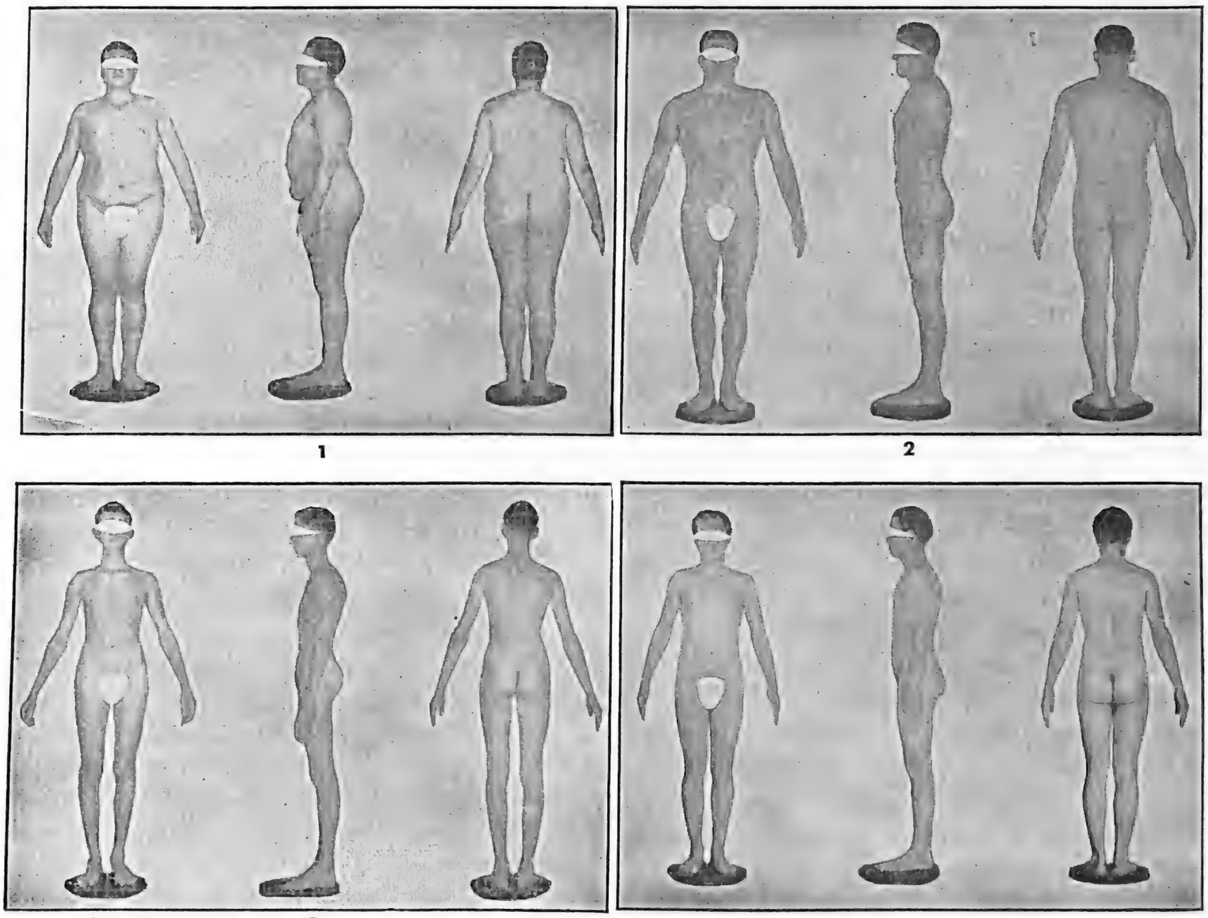
Your physique, as has already been suggested, is probably more important from the standpoint of how others react to it than for its own sake.

Some have tried to type individuals in terms of physique and have claimed that each physical type is characterized by a certain type of personality.[35]

The most recent, and the most ambitious attempt to correlate personality traits with physique avoids the mistake of trying to fit individuals into a few fixed classes. It also substitutes anthropometric measurements of many body parts for the general over-all estimates of earlier investigators.[36]

Hundreds of individuals were required to assume a standard posture while being photographed from front, side, and back. After one thousand photographs were available, these were arranged in series, in order to see whether types were evident. Actually, there were no types in the ordinary sense of the word, but "there were obvious dimensions of variation."

As various arrangements of the photographs were made, three "dimensions" were discerned, viz.: (1) *endomorphy,* greater or



299

Predominant Endomorphy, Mesomorphy, and Ectomorphy Compared with Average Physique

Each primary dimension is represented on a seven-point scale. The individual's somatotype is given in terms of his degree of endomorphy, mesomorphy, and ectomorphy, each number representing the respective degree of each. The predominant endomorph represented here (1) *is somatotyped 7–1–1½, meaning a maximum degree of endomorphy, a minimal degree of mesomorphy, and a close to minimal degree of ectomorphy. The predominant mesomorph (2) has the somatotype 1–7–1½; the predominant ectomorph (3) the somatotype 1½–1½–7; and the average individual* (4) *the somatotype 4–3–4. In the latter case the three dimensions are approximately at the center of the dimensional extremes. (From Sheldon, W. H., and Stevens, S. S.,* The Varieties of Temperament. *New York: Harper, 1942, between pp. 8 and 9.)*

less prominence of the abdominal region or digestive viscera; (2) *mesomorphy*, greater or less prominence of bone, muscle, and connective tissue; and (3) *ectomorphy*, greater or less prominence of fragile structure — long delicate bones, large surface area in proportion to mass. Extremes of endomorphy, mesomorphy, and ectomorphy are illustrated in Figure 299.

This scheme provides a good method of classifying physiques, but how about the relation between physique and temperament, since ancient times regarded as the aspect of personality that goes with a certain physique? Temperament is a concept which embraces much of what is more generally called personality. It includes such aspects as joviality, melancholia, tenseness, and activity level. In an effort to discover the possible relation between somatotypes and temperaments, the investigators developed rating scales for temperament and applied them to two hundred young men who had been somatotyped. Factor analysis of the items on which temperament ratings were made suggested three groupings to which the following names were given: *viscerotonia* (relaxation, love of comfort, amiability, etc.); *somatotonia* (need for action, directness of manner, competitive, etc.); and *cerebrotonia* (restraint, shyness, hypersensitivity, etc.). The subjects were rated for each of these traits on a seven-point scale corresponding with that used to somatotype them. A person's temperament could thus be rated for the degree to which he exhibited viscerotonia, somatotonia, and cerebrotonia. Here are three cases exhibiting predominance of one of the three dimensions of temperament.

Viscerotonia predominant [37]

Somatotype 5–3–3. Temperament 6–3–2

He has integrated his life around the supposedly popular *persona* of joviality, gluttony, and expansive complacency. He is known as a "bluff," or as a "bag of wind," but is a good-natured, well-meaning, and tolerable person in his rôle. He plans a journalistic career. He reads widely but superficially, and blandly reveals an astonishing ignorance in complex fields at every opportunity. He knows he is a bluff, but feels that journalism has lots of room for a good bluff.

Somatotonia predominant [38]

Somatotype 3–6–2. Temperament 2–7–1

One of those vigorous little fellows (short stature) who makes up for his lack of size by boiling over with energy. He wears hard heels and makes the house shake when he walks. A star basketball player, his short legs move so fast when he runs that they can hardly be seen. His posture is so straight and upright, and his chest is typically thrown so aggressively forward, that he suggests a pigeon in mating season. He is aggressive, but for some reason, which is not altogether clear to us, he is not offensively aggressive. Almost everybody knows him, and likes him. He is often called Napoleon, but always good-naturedly.

Cerebrotonia predominant [39]

Somatotype 2–4–5. Temperament 1–3–7

So pitifully cerebrotonic, so tense and apprehensive, so schizoid and overwhelmed with restraint that interviewing him is a painful experience. No vocational adjustment seems possible for him except one of the most protected nature. Library work has been suggested, but this involves graduation from college, which seems nearly impossible. We believe that such a situation as this can sometimes be met successfully by keeping the boy out of college until he is two or three years older than the average of his class, then sending him to a small college where girls predominate numerically.

Since the same investigators developed the somatotyping schema and the temperament scale, since they had a tripartite classification of each, and since dimensions of physique and temperament were rated on a similar seven-point scale, it is not surprising that high correlations between somatotype and temperament ratings were found. These correlations were in the neighborhood of .80.

The investigators admit a possible bias, but feel that it was not entirely responsible for the correlations found.

Some support for the above findings comes from a study in which, out of 50 predominantly ectomorphic students, forty-two were rated predominantly cerebrotonic, one somatotonic, one viscerotonic, and six without dominance of any dimension.[40] Only in the extreme of a dimension would one expect such relations to show up so clearly.

Further research will be necessary before the alleged correlation between physique and personality can be definitely established or discredited. Most of the work on physique and temperament has utilized post-adolescent college students. A study of the body forms of people in middle and late life may be necessary before a complete relationship can be worked out between physique and temperament. Should a significant relationship between physique and temperament be established, another question will remain, namely, the basis of the correlation. One would not be justified, on the basis of a significant correlation between the two, in jumping to the conclusion that physique determines temperament, or vice versa. Both may depend to a large degree upon glandular constitution. It is possible, too, that temperament is influenced to some degree by how others react to our physical characteristics. If we are predominantly endomorphic, people may react in a jovial fashion and expect us to be jovial. We, in turn, may adopt this role. Indeed, the social and constitutional influences in development of personality can seldom be separated.

The neural influence

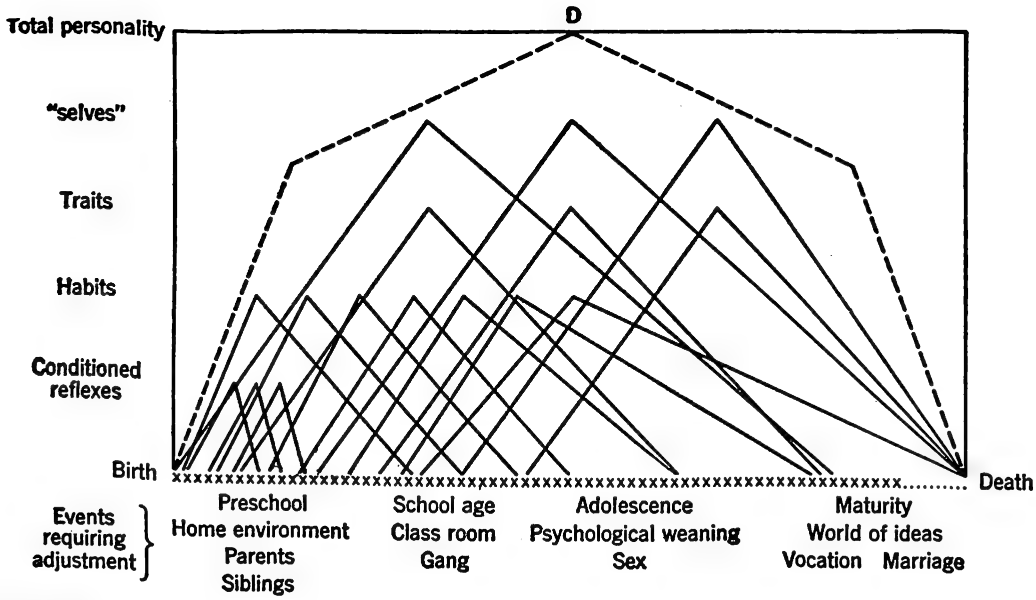
It is obvious that our intelligence, our insight into social situations calling for new adjustments, and the readiness with which we "adopt" new modes of response are related to the plasticity — or susceptibility to modification — of our nervous system. Injury to the brain is often followed by very extensive personality changes, partly through its obliteration of the traces of what we have learned and partly through interference with memory and thinking.

Some have sought to associate certain personality traits, and especially the temperamental, with functioning of the autonomic nervous system. One psychiatrist has constructed an elaborate theory of personality, normal and abnormal, in which a major place is given to "segmental cravings" resulting from conflict between the two autonomic nervous systems.[41] Many such cravings stem from the physiological drives that we discussed in earlier chapters. These cravings do exist and they are dominated, in a sense, by the autonomic system, but this psychiatrist seems to overemphasize their significance for personality.

THE SITUATIONAL INFLUENCE

From the time of birth until the time of death, we are thrown into one social situation after another, each of which may leave its imprint upon our personality.

You would possess a very different personality if you had been brought up by the Eskimos, the Sioux, the Balinese, the Arapesh, or by some other cultural group. Not only would you dress differently, live in a different kind of dwelling, eat different food, use different implements and weapons, and have different social customs, but you would also have a very different conception of the world and of your own place in it. Cultural anthropologists have rightly placed much emphasis upon the "socio-cultural matrix" in which personalities develop.[42] If you were reared in the United States, you have doubtless acquired a way of life, and with it, a personality, which an outside observer might well characterize as "typically American." But, even within this cultural matrix, aspects of your personality might well differ depending upon whether you were reared in the



300

A Schematic Representation of Personality Development and Integration

Along the abscissa are examples of significant situations and events requiring adjustment as the individual grows. On the ordinate are some examples of integrations involved in the total personality. Some of the points which this diagram serves to illustrate are: (1) Hierarchical organization. Conditioned reflexes predominate soon after birth; then habits (some as integrations of conditioned reflexes) appear. These are organized into more inclusive patterns still, referred to as "traits." Personality as a whole is the over-all integration of conditioned reflexes, habits, traits, and "selves." (2) The higher integrations (traits and "selves") are represented as appearing relatively late in the chronological sequence. Traits and "selves" are shown as becoming well established only after the preschool age. (3) There is a series of crises to be met as the individual grows and these may leave their impression. Psychological weaning, the onset of sex life, the need for finding a vocation, and marriage are critical events. (4) Each person may, to some extent, be regarded as having different "selves" rather than a completely integrated "self." He manifests one "self" at home, say, and another "self" in his place of business, in his church, in his club, and so on. Normally there is much overlapping of the different "selves," as they are integrated one with another; but some individuals, like Dr. Jekyll and Mr. Hyde, develop widely dissociated "selves" — so much so that we say that they have "dual personalities." Cases of as many as four rather widely different personalities in the same individual have been reported. One integration dominates, the others of course playing a minor rôle. While one personality is dominant, the individual may recall nothing of the others. The chief integrating factor in personality may be a predominant motive, represented by the enclosing dotted line *D*. This motive (see pp. 291–292) may be a desire for recognition, a desire to serve one's fellow men, to make a fortune, or the like. (After Allport, G., *Personality.* New York: Holt, 1937, p. 141; for further implications of this diagram, see his pp. 141–147.)

North or the South, the East or the West; whether you were reared in the country, a city or a town; whether you grew up in the slums or in the best residential section; whether your early life was spent in a house or an apartment; whether your parents were rich or poor, together or separated, cultured or uncultured, religious or irreligious; whether you went to a standard, sub-standard or superior school; whether you had or did not have close friends; whether they conformed or failed to conform to the mores of our culture; and so on.

Such socio-cultural influences are focused upon a child from the moment of birth and they continue to influence him all the days

of his life. Some are most influential in the early years and some not until the upper levels of maturity are reached.

Figure 300 is a schematic representation of sequentially developing situations requiring adjustment in our society and how they influence personality. This figure and its legend should be studied carefully. They put in a "nutshell" what would otherwise require a very extensive essay on personality development as a function of age. The following discussion does no more than highlight a few of the situational contributions to personality.

Beginnings of response to social situations

The baby is usually a month or more old before it becomes responsive to social situations as such. It is only then that it smiles at an adult, ceases to cry when picked up, and differentiates between human and nonhuman sounds. Later, it learns to differentiate the familiar and the unfamiliar. At about the middle of the first year, it differentiates friendly and unfriendly vocalizations and gestures.

When babies of the same age are placed in a crib together before the age of four months, they pay no attention to each other. They are well beyond the half-year before they overtly interact in such ways, for example, as offering each other toys and copying each other's actions. Domination of one by the other appears at about this time. The child is usually a year or more old before he keeps up social contact with more than one child at the same time. What he does, usually, is to react to one and completely ignore the other. Not until the age of five or six years are groups of three interacting children much in evidence.[43]

Home influences

The most important early contacts are of course those between a child and its parents or guardians. These provide, so to speak, a focal point for the culture. Parental behavior — whether stern or affectionate, permissive or prohibitive — is often culturally patterned, as already (p. 287) suggested. Within our own culture, however, child care and training, although culturally patterned in many respects, leaves much to the discretion of the parents. If a child's parents are repressive and without overt affection for the child, this often leads to introvert tendencies, the child withdrawing into a world of fantasy where, perhaps, he does what his parents will not allow him to do and he finds the affection denied him in real life. This is not the inevitable reaction to suppression and lack of affection, however, for the child's temperament, which is doubtless partly inborn, plays a role. The same situation, although fraught with the possibilities suggested, may actually lead to resistance and a show of defiance. "The same fire that melts the butter hardens the egg."[44]

On the other hand, the parents may be overindulgent or overaffectionate, and they may encourage the child to "show off" in the presence of others, making him more extraverted than he might otherwise be. Then, too, they may encourage the child to look to them for important decisions, creating a dependence that, with continued encouragement, may carry over into adult life. One mother may ask a child what kind of cereal he would like for breakfast, what book he would like to have read to him, which suit he would like to wear, and so on, requiring him to make his own decisions early. Another mother may give him what she thinks he ought to have and herself decide what he ought to wear and what he ought to have read to him. The second mother, wittingly or unwittingly, is encouraging dependency rather than independence.

How the parents react to curiosity about sex, what they say about relatives, about neighbors, and so on, all have possible effects.

Some parents continually go bull-headedly

into conflict situations within the home, while others, like the mother elsewhere mentioned (p. 375), get around them in a manner conducive to eventual harmony and a minimal display of emotion. Children are greatly influenced in their attitudes toward the parents by the attitudes assumed by the parents in such situations.

There is literally no end to the examples of home influence that one might give. The above illustrations serve to point out that it is very important for development of personality. Several recent documentary films (Figure 301) have especially stressed the mother's influence. The same home situation does not, of course, always have the same effect. The child may become like the parent or just the opposite; he may conform or not, depending upon the sort of individual he is constitutionally and also upon influences outside the home.[45]

The only child

There has been much talk about only children having "spoiled" personalities, but psychological investigation has shown that, while some only children may be "spoiled," the personality of only children as a group is not different from that of children with sisters and brothers. One method has been to match only and not-only children for age, sex, socio-economic status, family organization, and I.Q. Personality tests were then given to the matched groups, which consisted of thirty children each. Teachers also rated the children for various traits. There were small differences, sometimes in favor of the only children and sometimes in favor of the not-only children. The chief difference was that the only children had a few more "sissies" and "tomboys" among them than did the not-only children.[46] The tests have not measured such aspects of personality, however, as egocentricity, selfishness, and the like. What tests along these lines would show is problematical.

Onliness has possibilities fraught with danger to normal development, but these are only possibilities. What is more important than onliness as such is how the parents handle the situation. If the child has other children to play with — at home, in the neighborhood, or in a nursery school — and if his parents do not center too much attention upon him, there is no reason why he should be handicapped by his onliness.

Much has been written also about the youngest child and the oldest child in a family. Testing of children in different positions of the family hierarchy, however, has failed to show any evidence that birth-order on the average is related in any significant manner to the kind of personality developed. In individual cases, however, the fact of being an only child, or a child in some special birth-order, may be important in determining the personality of the child in question.[47]

Other social situations

After the family situation there come, of course, the influences of the neighborhood, community, Sunday School, preschool, school, church, gang, and so on. Each such situation may leave its mark. Comradeships within any of these situations have, of course, possibilities for good or ill. The situations themselves, like the home situation, may have unpredictable effects on personality. School makes scholars out of some children, while it makes other children haters of school and anything relating to it.

In high school, college, and business or professional life, the situations that we meet may have an influence on certain of our personality traits. But we are more resistant to change at these levels than earlier because, once certain habits and attitudes are acquired, they are somewhat resistant to change. This resistance to change has already been mentioned in connection with so-called "force of habit" (p. 294). Even

A

B

C

301

Documentaries on the Maternal Influence

A. Margaret, the central figure of *The Feeling of Rejection* is shy, non-competitive, and afraid to take independent action. As a child she was made to fear her over-protective mother's disapproval.

B. Clare, the successful editor of *The Feeling of Hostility,* has an under-developed capacity for love and friendship. Her father's death during her early childhood, her mother's remarriage and lessened attention to her, the coming of a baby brother, and school situations where her desire for affection was thwarted, led Clare to develop a hostile attitude toward others. She over-compensated by doing things that aroused the admiration of others for her intellectual ability.

C. Jim, of *Over-Dependency,* is a talented young married man who, despite physical fitness, suffers periods of illness which interfere with his work. Without realizing it, he has become over-dependent upon his wife and his too-indulgent mother and sister. He uses illness to obtain comfort, especially when faced with difficult tasks. (Courtesy National Film Board of Canada, 620 Fifth Avenue, New York 20, N. Y.)

though many individuals could change their personality in certain respects, especially by reacting differently to social situations, they seldom do so. One reason is that they are often pretty well satisfied with themselves as they are. This prevents them from recognizing that they may have traits which could be improved. Here, in this connection, is some good advice from a radio talk on "How to Grow a Personality" given some years ago by one of our most famous psychologists:

> But what can we poor adults do for ourselves, all encrusted over as we are with years of thwarted personalities? Adult personalities are hard to change. There are some things we can do, but you must have "guts" to go through with it, for it will take a long, long time.
>
> The first thing to do is to make a vocational and emotional survey of yourself. Take a piece of paper and put down your assets on the vocational side. How many things can you do, well enough to earn your living provided you lost your major job? Can you tell stories well? Can you take a group of children and entertain them? Can you play some musical instrument well enough to have a group gather around you and sing and play with you? Can some hostess call you in and depend upon you to help entertain her guests? Can the community depend upon you to help out in its problems? Then put down your liabilities. In your job what are your weaknesses? Do you watch the clock to see how soon the day will be finished? Do you take to criticism kindly? Do you contribute new ideas, or do you slavishly follow a routine? Are you growing and is your job growing?
>
> In a similar way put down your emotional liabilities and assets. Is your besetting sin grouchiness? Are you fretful over delays because things are not going ideally? Must you constantly be having commendation from your boss? In other words, must you have notice from those over you? Are you fretful and irritated at home with your wife or children? Do you feel that life has engulfed you and that you haven't a chance, and that the world owes you a living and is not giving it to you?
>
> When you have made this inventory of yourself you will be in a position to tell why you are not getting along better on your job, in your home, and in life generally. Begin to enlarge your inventory. If you are a moper at home, playing cards every evening, make plans to go out. Begin reading real books instead of trash, seeing good plays or good movies. Get yourself a few hobbies, be they wood carving, tooling leather, or carpentry. Add two or more sports that you have to play with others.
>
> Your emotional side is very difficult to handle alone, but even here you can do something. In the first place you can organize your life so that your emotional liabilities get less in the way. . . . In your strife for a new personality keep your efforts to yourself; don't let anyone know about it. In a year or two — not sooner — you will find that your old personality has begun to crack around the edges. Soon you can shed it. Your new personality won't be perfect — you can't get rid of your past completely — but it will please you more than your present one because you yourself made it to fit your present environment.[48]

A value of personality tests, rating scales, and inventories is that they aid in making inventories of strong points and liabilities. Unless the weaknesses are recognized by the person who has them, he stays in his "rut," and may even be complacent and self-satisfied about it. Sometimes, however, the situation forces a new type of adjustment, or, if it doesn't force a change, at least becomes conducive to such a change. One of the most interesting examples of this is the following experiment:

> A small group of college men agreed to cooperate in establishing a shy and inept girl as a social favorite. They saw to it . . . that she was invited to college affairs that were considered important and that she always had dancing partners. They treated her by agreement as though she were the reigning college favorite. Before the year was over she developed an easy manner and a confident assumption that she was popular. These habits continued her social success after the experiment was completed and the men involved had ceased to make efforts in her behalf. They themselves had accepted her

as a success. What her college career would have been if the experiment had not been made is impossible to say, of course, but it is fairly certain that she would have resigned all social ambitions and would have found interests compatible with her social ineptitude.[49]

NORMAL AND ABNORMAL PERSONALITY

What is a normal personality? What is an abnormal personality? The answer to these questions is not easy to find, for the words "normal" and "abnormal" have different meanings for different people. From the so-called normative view, anybody who is different from the one making the judgment is abnormal. In terms of the statistical view, however, anybody is abnormal who diverges very much from the average. In other words, the average person, according to this view, is the most normal one. From the purely social viewpoint, the normal person is the one who is adjusted to his environment to such an extent that he finds life enjoyable, and the abnormal one is the unadjusted — the one, in extreme cases, who would like to "get away from it all." To complicate the matter further, each of us may toe the normative, statistical, or social line with respect to some traits and not with respect to others. Moreover, we may be adjusted at times and not at others: for example, in a case of emergency or disaster. Generally speaking, however, the individual is regarded as normal if he has some socially acceptable goal around which his activities are integrated, if he finds the pursuit of his goal worth-while, and if, in general, he gets pleasure out of living. The person who has no socially acceptable goal, who is at cross-purposes within himself and with his group, and who does not enjoy life as it is, but tries to shut himself off from it, is, generally speaking, regarded as having an abnormal personality.

It is well to recognize, however, that what passes for a worth-while goal in one society or social group does not necessarily pass for a worth-while goal in others (pp. 287–289). Moreover, what is perfectly normal behavior in one society may be abnormal in another. The Central Australian aboriginal goes naked all the time, and this casts no reflection on his personality. But if you follow his example in "civilized society," you will be regarded not only as abnormal but as a criminal as well. To belong to a nudist society in a civilized country may also be significant in regard to the individual's personality.

Although it is difficult to draw any well-defined line between what is normal and what is abnormal, there are certain well-characterized abnormal personality types. These, as suggested in Chapter 1, are classified in two ways. One classification is in terms of whether the abnormality is *structural* or *functional* and the other in terms of whether it is a *psychoneurosis* or a *psychosis.*

The structural or organic personality disorders are those which have a known organic basis, like syphilis of the nervous system or hardening of the arteries of the brain.

Functional disorders, on the other hand, have no known organic basis, except acquired modifications of the nervous system which underlie the individual's peculiar attitudes toward himself and others.

Psychoneuroses (or neuroses) are much more prevalent than psychoses (known legally as insanities). Psychoneurotics are not ordinarily institutionalized. We find them in our homes, our churches, our schools, and scattered throughout any community. Although they may be a nuisance to those who have to associate with them, psychoneurotics are by no means dangerous. The psychotics, on the other hand, although not all in institutions for the mentally ill, are for the most part institutionalized. They occupy more hospital beds in this country than all the other ill put together. Each year, about seven hundred thousand individuals spend time in mental hospitals in the United States. This

is about one out of every two hundred persons in the general population.[50] Some psychotics get well, but there are always many more coming along to take their places. Not all these people are dangerous, but they are either unable to look after themselves or they are a burden upon those who must look after them, so that institutionalization is usually necessary.

All of the psychoneuroses are generally believed to be functional in origin. Some of the psychoses are believed to be functional and others are known to be structural, or organic. As suggested elsewhere (p. 14), functional disorders are based on acquisition of habits and attitudes rather than upon any destruction of nerve tissue, toxic interference with neural activity, or the like. The latter conditions underlie organic disorders.

The psychoneuroses

The classification of psychoneuroses most widely recognized until recent years was that which differentiated *neurasthenia, psychasthenia,* and *hysteria.* Today there is a tendency to break these down into a number of subclasses like anxiety hysteria, conversion hysteria, traumatic hysteria, and so on. For our purpose, which is merely to suggest some of the kinds of abnormal personality, the threefold classification will serve.

Neurasthenia. Literally, this is nerve weakness. It is characterized, in general, by lack of energy which is often accompanied by complaints of backache, headache, and the like. Here is an illustrative case from the files of a psychiatrist:

> Ever since I have been married I've been nervous. If I didn't have the finest husband in the world and one who takes wonderful care of me and puts up with all of my complaining and all my sickness, I'd be a grass widow. . . . I haven't been a wife to him at all. I've been too sick. First there was that awful headache. Oh, I can't tell you how terrible it was. It just knocked me down, and I thought the end of the world had come. . . . But there's been a lot of other things. There's a sort of internal trembling, you know, a kind of inward nervousness, and I feel as though all my organs were quivering. One doctor told me my nerves were tied in knots.
>
> I don't know why it is, but I can't stand anything. I haven't strength enough to walk from here to the streetcar and back. I may get up in the morning feeling pretty good, but by the time I get breakfast for my husband and have started on my morning's work, I'm nearly exhausted, and by noon I'm just completely played out. . . .
>
> I guess I told you about my sweating and getting so hot and then so cold. Did I tell you about that funny twisting feeling? It runs right through my right side down into my leg. I think it's a nerve loose or something like that. None of the doctors know what to make of my case. I've been to dozens of them. Yes, and I've tried osteopaths and chiropractors. I even went to the new psychology school and I don't know what all else. Some say I ought to try Christian Science, but you can't tell me these things are imaginary, and they are not in my mind either. I'll admit I'm nervous, but, there's a cause for these things somewhere. I know I never had 'em before I was married.[51]

Sometimes the individual with neurasthenia is helped by psychoanalysis or by non-directive therapy. Sometimes all that is necessary is a goal toward which he can direct his thinking instead of concentrating on bodily feelings. As a matter of fact, there are many successful treatments for such ailments. But patients often "hang onto" these ailments with grim earnestness like the shipwrecked sailor hangs onto a raft. Sometimes their ailments are "all they have." In many instances these give them a "good" excuse for failing to meet their obligations or to attain their level of aspiration in marriage, the business world, or elsewhere. Like anybody else, these unfortunates are trying to adjust to the situations of life. But instead of facing their problems in a realistic manner, they find escape through sickness. They do not do this intentionally, but they perhaps learned early in life that sickness excuses

one from many things, and even brings sympathy. They drift gradually, and unthinkingly, into these mental disorders. Sometimes they are merely following a pattern set in the home.

Psychasthenia. This term, which means "mental exhaustion," covers a variety of disturbances. Among these are extreme difficulty in making decisions, compulsions (to wash one's hands almost continually or to commit such acts as stealing or setting fires), and doubts and scruples. Quite generally there is a condition of morbid anxiety — anxiety that something terrible is about to happen, that one has not done what he ought to have done or has done something that he ought not to have done, and so on.

Since it covers so broad a field, the term "psychasthenia" has largely been given up, and we speak, instead, of compulsions, anxiety, neuroses, and so on. Many of the specific abnormalities which fall within this general grouping have origins similar to those mentioned in connection with neurasthenia. In many instances, too, the treatment is like that used with neurasthenics.

The following case is typical of the indecision and doubt that sometimes plague a person and which led to assignment of the term "psychasthenia" to such cases:

> A boy in high school was supplied with some second-hand books. He began to doubt the accuracy of them, for, as they were not new, he thought they might be out of date, and what he read might not be the truth. Before long he would not read a book unless he could satisfy himself that it was new and the writer of it an authority. Even then he was assailed with doubts. For he felt uncertain as to whether he understood what he read. If, for example, he came across a word of which he was not sure of the exact meaning, he could not go on until he had looked up the word in a dictionary. But likely as not in the definition of the word there would be another word with which he was not entirely familiar and he would have to look that up, so that at times half an hour or more would be taken up in reading a single page, and even then he would feel doubtful as to whether he had got the exact truth.[52]

Hysteria. This term also covers a variety of symptoms, some of which are often considered under their special names instead of under the general classificatory label. What holds all of these maladies together is the fact that they involve what has been called "dissociation." This may be defined as a state in which certain activities are no longer integrated with the rest of the personality. These activities are like bits of behavior "split off" from the rest, yet often coexisting with the rest. Such conditions may be simulated in the hypnotic trance, which is a fine example of dissociation (pp. 295–296).

Many so-called "shell-shock" or combat fatigue patients are victims of hysteria. Shock produced by shells has nothing to do with the origin of these disorders. Some of the symptoms of hysteria are sensory, such as hysterical blindness, deafness, and anesthesia (loss of cutaneous sensitivity). There are functional motor disorders, like twitching of muscles, paralysis of facial muscles or of limbs, and muscular spasms which may involve the whole body in such a manner as to lift the individual completely off his bed. There are memory disorders, like amnesia and fugue. The former is loss of memory such as one often reads about in the newspapers. A person with amnesia may wander off, forgetting his name and where he came from. The latter is a confused state in which an individual may commit some deed, perhaps murder, but later have no recollection of it. Multiple personality (Fig. 300, p. 590) also falls within this general classification. Finally, there may be so-called "hysterical fits," where the individual laughs or cries uncontrollably, perhaps goes into spells of uncontrollable rage.

Although there are many theories concerning the origin of hysteria, it is now generally conceded to come from mental conflict of the

kind considered in an early chapter (pp. 305–319). Sometimes it leaves spontaneously when the conflict situation which produced it has been resolved. Thus, soldiers stricken with hysteria often get well after the war is over. A man who was engaged and otherwise obligated to a girl with whom he was no longer in love disappeared and was found wandering around in the Midwest, having forgotten his name, the girl, and everything which would identify his past. The girl finally jilted him and he gradually recovered his memory. These and many similar cases may look very much like malingering, but there is ample evidence that assumption of such states is beyond the individual's control. He drifts into them gradually, perhaps wishing that a slight wound would send him home and out of danger, that he were not the person he is with the obligations he has, and so on. One interpretation is that he suggests or even "hypnotizes" himself into the states in question. As we have already suggested, most hysterical symptoms may be produced under hypnosis and they may also disappear while the person is hypnotized.

The treatment of such cases varies considerably. It is with such people as we have mentioned that various cults, like Dianetics, and forms of faith healing have their major successes.

It is with these people, too, that psychoanalysis achieves a certain degree of success.

The psychoses

The organic psychoses most clearly recognized are *paresis, senile psychosis,* and *alcoholic psychosis.* The chief functional psychoses are *manic-depressive psychosis* and *schizophrenia,* or *dementia praecox.*

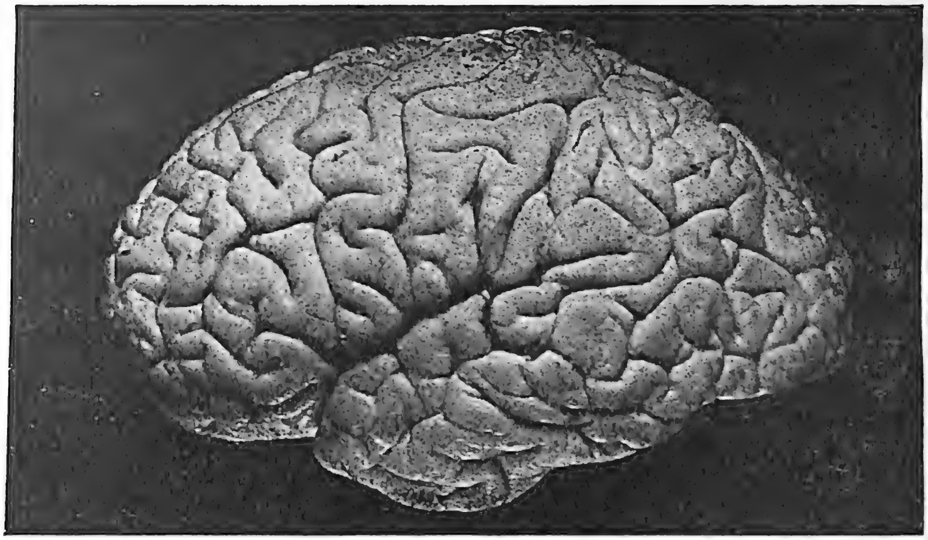
Paresis. Paresis is due to syphilis of the brain. (Figure 302.) But only a relatively small proportion of people who contract syphilis become paretic. If syphilis is treated and cured early, paresis never occurs. Paresis usually comes several years after all evidences of untreated syphilis have disappeared.

Here is the case of a person who contracted syphilis and was not cured, although all symptoms eventually disappeared and he thought he was cured. His paresis came on about thirteen years after he thought he was cured of syphilis. Brought before a class in abnormal psychology, he showed absence of certain reflexes and exaggeration of others, his speech was thick and he could not distinctly say such things as "black bug's blood." Moreover, he swayed slightly when his eyes were open, and a great deal when his eyes were closed. His walk was slightly tabetic (p. 483).

"Mr. ——, how are you feeling today?" "Fine, never felt better in my life!" "How are you off financially?" "Oh, I'm doing quite well. I have one billion dollars in the —— bank and another billion in the —— bank." "Have you any children?" "No. We had one, but it died at birth. I'm going to pick up a half dozen at —— Hospital on my way back to ——. I'm going to get four girls and two boys." "What are you going to name them?" "Well, I guess I'll name the four girls after the Dionne quintuplets." "Which ones?" "All of them." "But aren't there five quintuplets?" "Five! Well, what the hell!"

Before this patient came into the hospital, he was threatening to kill people who "had done him some wrong." He said he was not now mad at anyone. He was being given malaria and drug therapy and had shown considerable improvement since entering the institution. This is not necessarily a typical case, for every case is different in many respects. But delusions of grandeur (billions in the bank, picking up six children on the way home, and the like) are often found in such cases.

Senile and alcoholic psychoses. These also present a variety of patterns. Quite often there are delusions of one sort or another. One old man asked the doctor to bore a hole and let out some of the air that was pressing down on his brain, talked of people trying to



302

A Normal and a Paretic Brain

When a normal brain (top) is compared with a paretic brain (bottom), the cortical destruction in advanced paresis can be clearly seen. Not every paretic brain shows such widespread deterioration. (Top photo from Gardner, E., Neurology. *Philadelphia: Saunders, 1947, p. 11. Bottom photo from Jelliffe, S. E., and W. A. White,* Diseases of the Nervous System, *6th Edition. Philadelphia: Lea and Febiger, 1935, p. 821.)*

poison him, and so on. Such delusions are common in senile cases. There are also defects of memory. The patient may forget recent events. False memories may occur, as when the senile person tells you he did something a few moments ago that he could not have done because he was sitting before you in the room. Quite often there is disorientation, the patient not knowing where he is, what year it is, how long he has been in the institution, and so on. The picture for alcoholic psychosis is often similar to that for senile psychosis.

Manic-depressive psychosis. This disorder

is characterized by extreme ups and downs of mood. In the manic state the individual may be extremely happy, singing at the top of his voice, dancing around, working on inventions that will "shake the world to its foundations." He may also be so obstreperous that he must be kept under restraint of some kind. Delusions (p. 238) and hallucinations (p. 412) are often present. In both men and women, vile language, curses, sexual allusions, and sexual displays are common. Sometimes there is a "flight of ideas," the individual going off on one tangent or another as each idea occurs to him.

In the depressive state, these people present an even more pitiful picture. Many of them cry continually, accuse themselves of all kinds of sins, refuse to eat or drink because "it would be a sin to keep this evil body alive" and try to commit suicide. Such patients are, of course, tube-fed and watched closely to see that they do themselves no harm. The manic and depressive states alternate in a variety of ways. Some patients manifest only one state, with periods of normalcy in between. Others have a period of depression followed by normalcy, and then by mania.

Many people with manic-depressive psychoses get well. Some of them have written books about themselves, describing in detail their experiences in mental hospitals. Perhaps the best of these books are Clifford Beers's *A Mind that Found Itself* and Jane Hillyer's *Reluctantly Told.* Beers was largely responsible for improving the conditions in mental hospitals in this country, and indeed throughout the world. He was also largely responsible for the mental hygiene movement, the aim of which is to prevent the conditions and ways of thinking which produce manic-depressive and the other psychoses. Occupational therapy is one of the outstanding treatments for these patients. Some of them show great skill in weaving, carving, painting, and other arts.

Schizophrenia. This, literally, is a "splitting of the mind." It is now more widely used than the early term, *dementia praecox,* which means "youthful insanity." While this disease does usually make its appearance in youth, it often occurs in individuals ranging in age up to the middle years of life. There are four "types," but often so much overlapping that psychiatrists have difficulty in saying what type is present in a particular case.

Simple schizophrenia is characterized by general mental retardation. The patient sits and stares into space, has no ambition, would just as soon be riding freight cars, walking the street, or living in the institution as doing anything else. These schizophrenics give the appearance of being extremely introverted, living within themselves, and taking no interest in what goes on around them. It is seldom that anything can be done for them, and they stay in the institution until they die, sometimes at an advanced age.

Hebephrenic schizophrenia is characterized, above all else, by silliness and general incongruity of actions. A woman so classified was found in the men's room at the bus station with all of her clothes off, washing them, in fact, in the washbowls. She was laughing and generally silly about it. She even treated it as a big joke when it was discussed with her before a class. During the course of the session, she grimaced, made peculiar silly gestures, and failed to respond in a reasonable way to the questions asked her. She would probably giggle if told that her mother had died. One hebephrenic patient etched her name on her leg with a hairpin.

Catatonic schizophrenia is characterized by peculiar postures, waxy flexibility, and negativism. The patient may hold a particular posture for many hours. Sometimes, if the posture is changed by anyone else, he resists the change, and when he is released, resumes the former position. Sometimes he may be molded, hence the term "waxy flexibility." If his arm is put in a certain position by the doctor, he holds it in that position for

a long while. Sometimes the patient has not talked for years. The negativism which underlies this mutism is illustrated by the following example: The psychiatrist who was giving a clinic could not get the patient to speak and turned to the class saying, "This patient has not spoken for ten years," whereupon the patient said, "What do you want me to say?" These patients often have to be tube-fed and also carried around, when they refuse to eat or to walk. Sometimes, while sitting like a statue, they smile to themselves as if amused at something that is running through their heads. They are the most extreme examples of introversion that one could see. "Shut-in," "encapsulated," "insulated," are terms which aptly describe them.

Paranoid schizophrenia. This is in many ways the most spectacular of the four types of schizophrenia. It gets its name from the fact that paranoid delusions (delusions of reference) are often present. Some cases similar to these were described in our discussion of direction in thinking (p. 238). The patient has the idea that people are poisoning him, that ground glass is being put in his food, that his organs are all made of rubber, that he has no blood, that the F.B.I. is spying on him, and so on. Many cases so classified have delusions of grandeur rather than, or in addition to, those of reference. Quite often there is a wide variety of symptoms.

Mrs. —— was a successful nurse, but began to get the idea that she was being spied upon by her neighbors, that men were hiding in her attic at night with a view to seducing her, "an honorable woman." She is a great inventress, having invented a powderless, triggerless, shell-less, report-less, barrel-less gun — in fact a peace gun. She has sold it to the government, but German spies are everywhere in the institution and the superintendent is in league with them. She has the idea that there may be some spies in the class, so she asks everyone to raise his right hand and say, "God Save America." Then she is satisfied and continues with her harangue, hinting that even greater inventions are coursing through her mind. She switches to religion, telling what a pure righteous woman she is. She was "monkied" with ten years ago and is to give birth to five monkeys. She says her term is a long one because hers is a Caesarian case. Then she thinks of the boys at the front, and has everyone bow his head in prayer while she prays tearfully that God will "protect our boys." She then hands out some poetry that she has written. When the doctor says, "All right, Mrs. ——, you may go back now," she becomes quarrelsome, accusing him of not wanting these boys and girls to know that he is keeping her, a perfectly sane woman, in this place. She is edged out of the room, but slips a piece of paper to a girl sitting near the door. It says, "This is a house of ill repute, you had better get out of it while you have a chance."

Another patient has the delusion that he is dead. Asked, "Do dead people bleed," he replies, "No, of course not." His finger is then pricked and a drop of blood oozes out. "There, now," he is told, "you bleed, so you can't be dead." He replies, "Well, all that shows is that dead people *do* bleed."

Various treatments are used with schizophrenic patients, the most publicized of which are the insulin, metrazol, and electric-shock treatments.[53] All of these produce some "cures," but some schizophrenic patients, especially those in the types most helped by these treatments, get well anyhow. Some that are "cured" or get well spontaneously come back again. There seems to be little doubt that more are "cured" than get well spontaneously, but how long they will be able to stay well is a question that cannot be answered until the treatments have been in use longer. Why these treatments work is also problematical.

Then there is the treatment known as "psychosurgery." We have discussed this elsewhere (p. 69). It is infrequently used, and only as a last resort, for it involves serious brain operations. The results reported so far have been highly encouraging.[54]

SUMMARY

Personality has been defined as the most characteristic integration of an individual's structures, modes of behavior, interests, attitudes, capacities, abilities, and aptitudes — especially when considered from the standpoint of adjustment in social situations. Methods of investigating personality are divided, for convenience, into the following kinds: case history, rating, pencil-and-paper personality measuring devices, behavior tests, interviews, free association and dream analysis (psychoanalysis), and projective methods. Material used to illustrate these methods also illustrates a number of traits or dimensions of personality, including some of the so-called "depth" factors. Although some of these methods, depending on the purpose for which they are used, are more valid and more reliable than others, our discussion has not stressed evaluation. All methods that throw any light on personality are of some value.

Whether the newborn child does or does not have a personality is controversial, but there is no doubt that clearly recognizable personality traits are present in the first few months of life. More appear with age and experience, seeming to differentiate out of a pre-existing whole. Biological and situational influences are both significant for personality.

The biological influence is represented most clearly through the effect of glands on physique and temperament, the relation between physique and temperament, and the role of the nervous system in acquisition of personality traits. Injuries to the brain, as in syphilis, senility, and alcoholism, often lead to marked changes in personality. The autonomic nervous system also plays a role in personality, but how much weight should be given to its influence is problematical.

The situational influence begins soon after birth, especially when the child begins to respond to the behavior of others. It continues throughout life. Parents, friends, and teachers exert a powerful influence on personality, but exactly how the child will respond (whether positively or negatively, for example) is not determined by the social situation alone. It is influenced also by his biological makeup and what he has learned in other situations. Onliness does not doom a child to distortion of personality so long as social contacts with other children are provided and parents do not focus too much attention on the child. Habits of self-reliance can be started quite early in life as also can habits of dependence. Personality changes are greatest, of course, during childhood and adolescence, but they may also occur in adults. It is only rarely, however, that the personality of normal people changes very much after the adult level has been reached. Some suggestions for improving personality were quoted.

The normal person has some socially acceptable goal around which his activities are integrated, he finds pursuit of his goal worthwhile, and, in general, enjoys living.

Clinical types of abnormal personality are classified: (1) as structural or functional, and (2) as psychoneuroses (neuroses) or psychoses (insanities). All the psychoneuroses are believed to be functional. Some psychoses are apparently functional and some are structural. Functional personality disorders are due primarily to the mode of living and thinking acquired by the individual, but structural personality disorders are due primarily to damage within the nervous system, and especially within the brain.

As examples of psychoneuroses we described neurasthenia, psychasthenic disorders, and hysteria. Examples of structural psychoses were paresis and senile and alcoholic psychoses. The functional psychoses discussed were manic-depressive psychosis

and schizophrenia, or dementia praecox. Of the latter, four types, simple, hebephrenic, catatonic, and paranoid, were described.

Although our survey of abnormal personalities was primarily for the purpose of showing the kinds of disorder that occur, we mentioned briefly some of the causes and treatments. The whole topic of abnormal personality, with its description, origin, and therapy, is treated more thoroughly in the study of abnormal psychology, mental hygiene, and psychiatry.

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Appendix

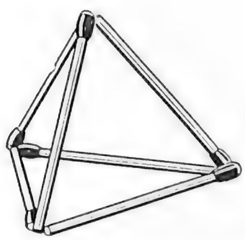
Photographs for recognition test, FIGURE 117, *p.* 212:

Indicate, by number, which twelve of the above faces appeared on page 212. Then turn back to that page and check your accuracy.

(Photographs used through the courtesy of the Vanderbilt Commodore.)

Solution for problems in FIGURE 131, *p.* 236:

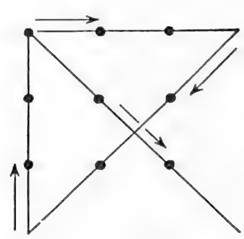
A. The six matches should be arranged as here illustrated:



B. The area of the square is 16 units.

C. The tumor is treated by rays coming from different directions but coming to a focus at the tumor.

Solution for FIGURE 132, *p.* 238.
Begin at the top.



Answers for FIGURE 174, *p.* 365:

Expression 1. Terror or fear.

Expression 2. Grief or sorrow.

Expression 3. Surprise.

Expression 4. Hate.

(Expression 1, Ruckmick; 2, Sydney Morning Herald; 3, Life; *4, Feleky. Expressions 1 and 4 are posed expressions, courtesy of C. H. Stoelting Company.)*

Answers for FIGURE 177, *p.* 370:

Expression 1. Terror, fear, or horror.

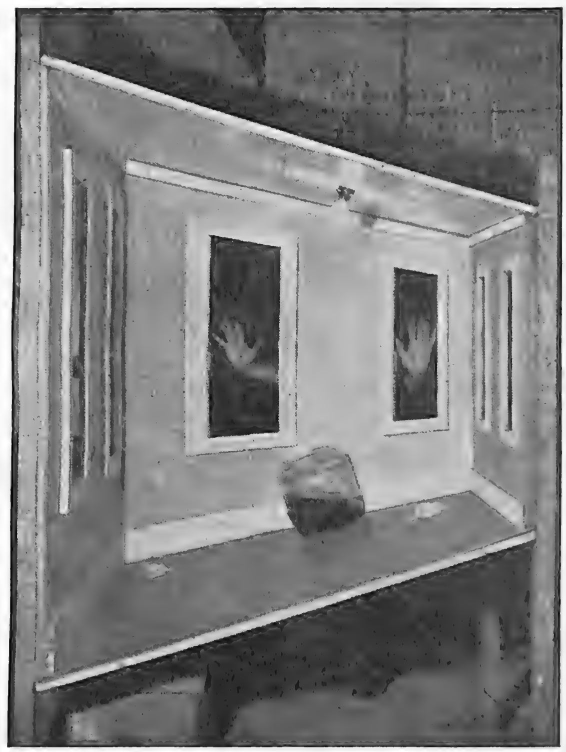
Expression 2. Disgust.

Expression 3. Horror.

(Expression 1, Life; *2, Leonard Carmichael; 3, C. H. Stoelting Company.)*

Explanation of FIGURE 211, *p.* 437:

An exterior view of a distorted room similar to that shown on p. 437, showing how it is constructed to create the deceptive illusion.



(Photographed for Life *by Eric Schaal.* © Time, *Inc.)*

Solution for FIGURE 262, *p.* 518:

The correct sequence of pictures is: D, F, C, A, E, B

INDEX OF NAMES

Italicized numbers refer to references and suggested readings. Any other number refers to the page on which an author's contribution is discussed, even though a reference number rather than his name appears on that page.

Abel, L. B., 173–174, *194*
Adolph, E. F., 268, *282*
Adrian, E. D., 435, *445*
Aldrich, C. A., 131, 133
Allport, F. H., 340, *359*, 574, *603*
Allport, G. W., 210, *226*, *304*, 571, 574–575, 583, 590–591, *603–605*
Alm, O. W., 162, *166*
Alper, T. G., 318, *324*
Amatruda, C. S., 82
Ames, L. B., 84, *89*
Anastasi, A., 336, *358*, *544*, *549*
Andrew, G., 242, *254*
Andrews, T. G., *39*, 62, *166*, 231, *253–254*, 446, 451, *489*
Angell, J. R., 10
Anrep, G. V., 119
Arey, L. B., 77, 80, 92, *112*
Aristotle, 4, 6, 22
Armington, J. C., 60, 62, *73*
Armstrong, H. G., 268, *283*

Baar, J., 404–405, *416*
Babkin, B. P., *133*
Bacon, F., 6
Bagby, E., 295, *303*
Bair, J. H., 322, *325*
Baker, K. H., *506*
Baker, L., 312
Baker, R. F., 93, *112*
Barcroft, J., 321, *325*
Bard, P., 325–353, *359*
Barelare, B., 263–264, *282*
Barker, R. G., *90*, *113*, 316–317, *324–325*
Bartelmez, S. W., 50
Bartlett, F. C., 206–208, *225–226*
Bartlett, S. C., 234–235, *253*
Bartley, S. H., 431, 434, 445–446
Bash, K. W., 262, *281*
Bass, M. J., 122, 127, *132*
Bateson, G., 278
Bayley, N., 510
Beach, F. A., 266, 274–275, 278, *282–284*
Beatty, R. T., 469
Beaumont, H., 363–364, *381*
Bechterev, V. M., 119, 122, *133*
Beck, L. F., 296, 313–314, 439, *446*
Beck, L. H., 472, *488*
Beck, S. J., 581, *604*
Beers, C., 600
Békésy, G. V., 459, *469*
Bell, J. E., *604*
Bellinger, L., 147
Bennett, G. K., 556
Bergman, E. R., *546*
Bernreuter, R. G., 577, *603*
Berrien, R. K., 399, *568*
Bieber, M., 570
Bijou, S. W., 319, *325*
Bills, A. G., *399*, *446*
Bilodeau, E. A., 179–180, *194*
Binet, A., 509, *542*
Bingham, H. C., *38*, 274–275, *283*
Bingham, W. V., 547, *567–568*
Birch, H. G., *24*, *74*, *90*, *113*, *133*, *166*, *226*, *254*, *284*, *304*, *325*, *360*, *399*, *417*, *506*, *544*, *568*, *605*
Bird, C., *284*, 301, *304*
Blatz, W. E., 335, 349, *358–359*
Bliss, E. L., 391–392, *398*
Bolles, M., *74*, *605*
Boring, E. G., 8, *24*, 53, *74*, *255*, 345, 408, *416*, 432, *445–446*, 455, 459, 462, *469*, 486, *489*, 519–520, 532, *543*, *550*
Bousfield, W. A., 120
Boynton, P. L., 525, *543*
Bradshaw, F. F., 572, *603*
Braid, J., 16
Brandt, H. F., 388–389
Bray, C. W., 459–460, *469*
Bretnall, E. P., 174, *194*
Breuer, J., 16
Bridges, K. M. B., 331–332, 340, *358–359*
Brill, A. A., *604*
Britt, S. H., 337–338, *358*
Brogden, W. J., 172, *194*
Brooks, F. D., *90*
Brown, C. W., *568*
Brunswik, E., 408, *416*
Bryan, W. L., 155–156, *166*
Buchsbaum, R., 44
Buck, P., *544*
Buehler, C., 203–204, *225*, 336, *358*, 510
Bunch, C. C., 65, *73*
Burks, B. S., 519, *543*
Burnside, L., 84, *90*
Burton, A., *39*
Burtt, H. E., 201, *225*, *399*
Butler, S., 21
Buxton, C. E., 153, 191, *195*

Cameron, N., *605*
Campbell, A. W., 50
Campbell, C. M., *381*
Cannon, W. B., 262, 267, *281–282*, 347, 353–356, *359*
Cantril, H., 38, 293, *303*
Carliner, P. E., 486, *489*
Carlson, A. J., 50, *54*, *74*, 262, *281*, 348, *359*
Carmichael, L., 55, 69–70, 73, 90, 105–106, *112–113*, *226*, 228, *253*, 278, *284*, *303*, *360*, 412, *416*, *471*, 476, 478
Carpenter, C. R., *38*
Carr, H. A., 144, *165*
Carroll, H. A., *325*
Cason, H., 122, *132*, 364–365, *381*
Cattell, J. McK., 10–11, 508, *542*
Cattell, P., 510
Cattell, R. B., 571, *603*
Chapanis, A., *417*, *446*, 456, *469*, 565, *568*
Charcot, J. M., 16
Chave, E. J., 300, *304*
Chen, H. P., 87, *90*
Child, F. J., 206
Child, I. L., 293, *303*
Clark, S. L., 57
Cohen, N., 336, *358*
Cole, L. E., 385, *398*
Coleman, J. C., 329–330, *358*, 368–369, *381*, 596, *605*
Colin, E. C., *112*
Combs, A. W., 307, *326*
Conrad, H. S., 537
Cook, S. W., 319, *325*
Cotzin, M., 31–33, 39
Cox, C. M., 519, *543*
Cox, J. W., 150, *166*
Crafts, L. W., *74*, *133*, 169, *195*, *226*, *254*, *284*, *325*, *359*, *446*, *544*
Crawford, J. E., 558
Crocker, E. C., 471
Cronbach, L. J., *568*, *605*
Crosby, E. D., 111, *113*
Crozier, W. J., *489*
Crutchfield, R. S., 290, *303*
Culler, E., 57, *73*, 119
Curtis, Q. F., 318, *325*
Cushing, H., 64, *73*

Dallenbach, K. M., 8, 31–33, *39*, 217–219, *226*, 473–474, 479, *488–489*
Darwin, C., 10
Dashiell, J. F., *74*, *90*, *113*, *139*, 165, 188, 249, 332, *399*, *506*
da Vinci, L., 341
Davis, C. M., 263–264, *282*
Davis, H., 459, 464, 467, *469*
Davis, R. C., 343, *359*, 451
Deese, J., 119
Dembo, T., 293, *303*, 316–317, *324*
Dennis, M. G., 107–108, *113*
Dennis, W., *24*, *74*, *89*, 107–108, *113*, *133*, *166*, *195*, *226*, *254*, *284*, *325*, *359*, *382*, *399*, *417*, *446*, *469*, *489*, *544*, *605*
Deri, S. K., *604*
Descartes, R., 4–6, 22
Dewey, J., 236, *253–254*
Dexter, E. S., *24*, *39*
Dickens, C., 519
Dixon, W. J., 299, *304*
Dockeray, F. C., 211
Dodge, R., 484, *488*
Dollard, J., 141, 148, *165*, *304*
Donaldson, H. H., 67
Donner, G., 265
Doudoroff, M., 47, *73*
Droba, D. D., 300–301, *304*
DuBois, P. H., 560, *568*
Dudycha, G. J., 199, *225*
Dudycha, M. M., 199, *225*
Duffy, E., 328
Dunlap, K., 130, *133*, 484, *488*

Dunn, L. C., 96
Dunn, W. H., 373–374, *381*
Dusser de Barenne, J. G., 489
Dysinger, D. W., 350, *359*

Ebbinghaus, H., 214–215, *226*
Eckert, J. F., 263, 282
Edwards, A. L., *195*, 498, *506*
Edwards, A. S., 507, 522, *542*, *543*
Egan, J. P., *167*, *360*, 408, *416*, *446*, *469*, *489*
Einstein, A., 519
Elder, J. H., 68–69, *73*
Ellis, W. D., 216, *226*
Elsberg, C. A., 473
Elwell, J. L., 175–176, *194*
English, O. S., 373, *381*, *382*
Erickson, T. C., 64–66, *73*
Estabrooks, H. A., 222, *226*, 297, *303*
Evans, H. M., 92
Evans, R. M., *417*, 419, *445–446*
Ewert, P H., 157, *166*, 250, *254*, 429, *445*

Farnsworth, P. R., 363–364, 381
Farris, E. J., 276
Feinberg, M., 119
Ferguson, L., 269, *283*
Festinger, L., 293, *303*
Fields, P. E., 144, *165*, 242, *254*
Finger, F. W., 319, *325–326*
Finley, C. B., 171, *193*
Finner, P. F., 39
Fisher, R. A., *39*
Fitts, P. M., 566, *568*
Fjeld, H. A., 141
Flourens, M. J. P., 7, *23*
Foley, J. P., 120, *544*, *549*
Forlano, G., 182–183, *194*
Foster, D., 473–474, *488*
Foster, H., 158–159, *166*
Foster, W. S., 145
Frank, P., 519, *543*
Franklin, B., 309–310
Franz, S. I., 65–68, *73*, 387
Fredericq, L., 259, *281*
Freeman, F. N., 100, *112*
Freeman, G. L., 390–393, *398*
Freeman, W., 70, 251, *254*, 601, *605*
Freud, S., 16–17, *325*, 580, *603–604*
Frink, H. W., 597, *605*
Fromme, A., 106, *113*
Fryer, D., *568*
Fulton, J. F., *23–24*

Gagné, R. M., 158–159, *166*
Galambos, R., *39*
Galton, F., 10–11
Gardner, E., 59, *74*, 482, 599
Garner, W. R., *417*, *446*, 456, *469*, 566, *568*
Garrett, H. E., *39*, *74*, *133*, *166*, *195*, *360*, *417*, *446*, 499, *506*
Garth, T. R., 362, *380*, 522, *543*
Gates, A. I., 160, *166*, 182, *194*, 213, *226*
Gaudet, H., *38*
Gault, R. H., 169, *193*
Gay, L. N., 486, *489*
Gelb, A., *417*
Geldard, F. A., *489*
Gellermann, L. W., 234, *253*
Gengerelli, J. A., 139, *165*
Gesell, A., 82, 86, *90*, 110, *113*, 510
Ghiselli, E. E., *568*
Gilbert, M. S., 79
Gilbert, R. W., *74*, *133*, 169, *195*, *226*, *254*, *284*, *325*, *359*, *446*, *544*
Gillette, A. L., 213–214, *226*
Gilliland, A. R., 510–512, *542*
Glaser, N. M., 319, *325*
Glixman, A. G., 318, *324*
Goldberg, B., 585
Goldstein, K., 243–244, *254*
Goodenough, F. L., *38*, *90*, 332–335, *358*, 374–375, *381*, 512, 530, *542*, *544*
Gordon, K., 387
Gorer, G., 278
Gottdanker, R. M., 60, 62, *73*
Gottschaldt, K., 409
Graham, C. H., 393, *398*, 435, *445*
Granit, R., 435, *445*
Gray, F. E., 60, 62, *73*
Green, H. J., *546*
Greene, E. B., *506*, *544*, *604*
Griffin, D. R., *39*
Griffith, J. Q., 276
Griffiths, W. J., 319, *325*
Grindley, G. C., 175–176, *194*
Guilford, J. P., 215, *226*, 362, *380*, *382*, *506*, *568*, 575–576, *603*, *605*
Guillaume, P., 141, *165*
Gundy, J. Van, 304
Gurnee, H., 174, *194*
Guthrie, E. R., 130, *133*, 140, *165*, *195*, 287, *303*, 594–595, *605*

Hagman, E. R., 334, *358*
Hahn, G. L., 486, *489*
Hall, C. S., 174, *194*
Hall, D. E., 276, *283*
Halstead, W. C., 171, *193*
Halverson, H. M., 87, *90*
Hanawalt, N. G., 367–368, *381*
Harden, L. M., 219–220, *226*
Harlow, H. F., *73*, 203–205, *225*, 231, 242, *253–254*, 265, *282*
Harris, R. E., *39*
Harrower, M. R., *417*, 465
Harsh, C. M., 589, *604*
Hart, G., 121
Harter, N., 155–156, *166*
Hartley, E. L., *24*, *39*, *74*, *90*, *113*, *133*, *166*, *226*, *254*, *284*, *304*, *325*, *360*, *399*, *417*, *506*, *544*, *568*, *605*
Hartley, R. E., *24*, *39*, *74*, *90*, *113*, *133*, *166*, *226*, *254*, *284*, *304*, *325*, *360*, *399*, *417*, *506*, *544*, *568*, *605*
Hartman, C. G., 217
Hartmann, G. W., 338, *359*, *382*, *417*, *544*
Hartshorne, H., 578–579, *603*
Hathaway, S. R., 576, *603*
Haslerud, G. M., 68–69, *73*
Havighurst, R. J., 605
Hayes, C., 105
Hayes, K. J., 105
Healy, W., 146
Hebb, D. O., 69, *73*, 191, *195*, 199, *225–226*, *360*
Hecht, S., 425, 433, *445*
Heidbreder, E., 242–243, *254–255*
Helmholtz, H. v., 431–432, 460–461
Helson, H., 139, *165*, *419*, *445*, 566, *568*
Henmon, V. A. C., 533, *543*
Henry, E. R., *568*
Hepner, H. W., 288, *303*, *398*, 572, 579, *603*
Hering, E., 405, 409
Heron, W. T., 297, *303*
Herrick, C. J., 48
Hertz, M. R., 581, *604*
Hertzog, H., *38*
Hetzer, H., 203–204, *225*
Hevner, K., *382*
Hicks, V. C., 144, *165*
Hilgard, E. R., 122–123, *133*, *195*
Hillyer, J., 600
Hoagland, H., 58, *74*
Hogan, H. F., 412, *416*
Hollingworth, H. L., *255*, 395, *398*
Hollingworth, L. S., 526–528, *543–544*
Holmes, F. B., 376, *381*
Holmes, S. J., 98, *112*
Holt, E. B., 125, *133*
Holt, L. E., 263–264, *282*
Holzinger, K. J., 100, *112*
Honzik, C. H., 169, 173, 190, *193–195*
Hooker, D., 81–82, *90*
Hooker, H. F., 592, *604*
Horney, K., *604*
Horton, G. P., 140, *165*
Hoskins, R. G., 267, *282*, 586, *604*
Houlahan, F. J., 219, *226*
Hovland, C. I., 181, *194*
Hrdlicka, A., 85, *90*
Huber, G. C., 111, *113*
Hudgins, C. V., 122, *132*, 322, *325*
Hulin, W. S., *24*
Hull, C. L., 34, *39*, 122, 127, 184–187, 244–245, *254*, 297, *303*
Hunt, J. McV., 293, *303*, *325*, *382*, *604*
Hunt, T., 561, 568, 573–574, *603*
Hunt, W. A., 330, 342–343, 348, *358–359*
Hunter, F. R., 351
Hunter, G. W., 351
Hunter, W. S., *24*, 201–203, *225*, 233–235, 253, 322, *325*, 401, *416*
Hurlock, E. B., *113*, 175, 177, *194*, *360*
Husband, R. W., 144, *165*, 297, *303–304*, *399*
Hutchinson, E. D., 246, *254*
Huxley, J., 143

Iisager, H., 338, *359*
Ilg, F., *90*
Inbau, F. E., 371–372, *381–382*
Irwin, O. C., 84, 87, *89–90*, 331, *358*
Itard, J. M. G., 17–18
Ivanov-Smolensky, A. G., 121

Jackson, T. A., 69, *73*, 140–141, *165*
Jacobson, C. F., 68–69, *73*
Jacobson, E., 241, 250, *254*, 322, *325*
Jaensch, E. R., *226*
James, W., 221, *226*, 245, *254*, 294, *303*, 353–357, *359*

Janet, P., 16
Jastrow, J., 604
Jeffers, V. B., 419, *445*
Jelliffe, S. E., 599
Jenkins, J. G., 34, 217, *226*
Jenkins, M. D., 522, *543*
Jenkins, T. N., *73*
Jenkins, W. L., 479, *488–489*
Jenkins, W. O., 566, *568*
Jensen, D. W., 519, *543*
Jensen, K., 83
Jerome, E. A., 473
Jersild, A. T., 336–337, *358*, *360*, 376, *381*
Jersild, C. L., 336–337, *358*
Johannsen, D. E., 369–370, *381*, *417*
Johnson, B., 439–440, *446*
Johnson, E. P., 122, *132*
Johnson, V., 50, 54, *74*, 262, *281*
Jones, H. E., 334, *358*, 537, *543*, 592, *604*
Jones, L., 522, *543*
Jones, M. C., 334, *358*, 376, *381*
Judd, C. H., 161–162, *166*
Jung, C. G., 372, *381*

Kalish, D., 187–188, *195*
Kao, D. L., 155, *166*
Kappauf, W. E., 407, *416*
Kappers, C. V. A., 111, *113*
Katona, G., 161, *166*
Katz, D., 269, *283*, *417*, 419, *445–446*
Keeler, L., 370
Keller, F. S., 24, 152, *166*, *417*
Keller, H., 168
Kellogg, L. A., 104–105, *112*
Kellogg, W. N., 104–105, *112*, 119, 153
Kemp, E. H., 461, *469*
Kempf, E. J., 589, *604*
Kennedy, J. L., 60, 62, *73*
Kepner, R. D., 531, *543*
Key, C. B., 522, *543*
Kimble, G. A., 125, *133*, 179–180, *194*
Kingsley, J. S., *166*
Kinsey, A. C., 267, *282*
Kitson, H. D., 155, *166*, 299, *303*
Klee, J. B., 319, *325*
Klein, D. B., *326*, *605*
Kline, L. W., 369–370, *381*
Klineberg, O., *304*, 334, *358*
Kluckhohn, C., 277, *283*, 589, *604–605*
Klüver, H., 209, *225*, 433, *445*
Koch, A. M., 141
Koffka, K., *417*
Köhler, W., 141–142, *165*, 394, *398*, 409, *416*
Kohs, S. C., 531
Kounin, J. S., *90*, *113*, 317, *324–325*
Kraines, S. H., 605
Kreezer, G., 62
Kreindler, A., 124
Krech, D., 290, *303*
Kretchmer, E., 586, *604*
Krueger, W. C. F., 215–216, *226*
Kuder, G. F., 552–553, *568*
Kuhlman, F., 521, *543*

Laird, D. A., 470, *488*
Landis, C., 70, *74*, 343–344, *359*, *605*
Lane, C. E., 456
Lange, C., 353–357
Langfeld, H. S., 53, *74*, *255*, 408, *416*, 462, *489*
Lashley, K. S., 66, *73*, 137, 170–172, 181, *194*, 353, *359*
Lathan, C., 144, *165*
Latif, I., 88, *90*
Layman, J. D., 44, *55*
Leavitt, H. J., 200, *225*
Lee, G. E., *38*
Leeper, R. W., *326*, 328
Lenggenhager, K., 486, *489*
Lennox, W. G., 62, *73*
Leonard, W. E., 295, *303*
Leuba, C. J., 271, *283*
Levy, D., 271, *283*
Lewin, K., 147, *165*, 293, *303*, 307, 316–317, *324*, 583–584, *604*
Lewis, D., 562, *568*
Liddell, H. S., *326*
Lindesmith, A. R., *303*
Lindquist, E. F., 504, *506*
Lindsley, D. B., 62, 82, *89*, 322, *325*
Linton, R., 289
Lippmann, H. S., 86, *90*
Locke, J., 17
Lockhart, A., 149, *165*
Louttit, C. M., 10
Luchins, A., 240, *254*
Luckhardt, A. B., 262–263, *281–282*
Lund, F. H., 348–351, *359–360*
Luria, A. R., *326*

Machover, K., *604*
Maier, N. R. F., 137, 229–231, 239, *253*, 306, 308–309, 319, *324–326*
Maller, J. B., 577–578, *603*
Malmo, R. B., 69, *73*
Marinesco, G., 124
Markey, F. V., 336–337, *358*
Marquis, D. G., 97–98, *112–113*, 122–123, *133*, *195*
Marston, L. R., 577–578, *603*
Martin, C. E., 267, *282*
Maslow, A. H., 203, *225*, *304*, 592, *604*
Massermann, J. H., 352–353, *359*
Mateer, F., 122, *132*
Mathews, R., 435, *445*
Maurer, K. M., 35–36, *39*, 530
Max, L. W., 250, *254*
Maxick, 322, *325*
May, M., 149, *165*, 577–579, *603*
Mead, M., 287–288, *303*
Mees, C. E. K., *23*
Melton, A. W., 200, *225*, 555
Meltzer, H., 337, *358*
Menninger, K., 267, *282*, 596, *605*
Menzies, R., 122, *132*, 322, *325*
Merrill, M. A., 494, 502, 512–520, *544*
Mesmer, F. A., 16
Metfessel, M., 106, *113*
Mettler, F. A., 57, *73*, 119
Meyerson, I., 141, *165*
Miles, C. C., 537
Miles, W. R., 269, *283*, 472, *488*, 537, *543*
Mill, J. S., 519
Miller, D. C., 453
Miller, N. E., 121, 141, 148, *165*, *326*
Millichamp, D. A., 335, *358*
Minami, H., 217–220, *226*
Mirsky, A. E., *112*
Mittelmann, B., *304*, 592, *604*
Mohr, G. J., 276, *283*
Moore, A. R., 47, *73*
Moore, J. E., 365, *381*
Morgan, C. T., *74*, *133*, *195*, 263, 268, *282–284*, 353, *359*, 417, *446*, 456, 459, *469*, 471, *489*, 566, *568*
Morgan, J. D., 262, *281*
Morgan, J. J. B., 130, *133*, 262, 331, *358*, 390, *398*
Morgensen, A. H., 150
Morgulis, S., 119
Morpurgo, B., 111, *113*
Moss, F. A., 269, *283–284*, *304*, 562, 573–574, *603*
Mowrer, O. H., 130, *133*, 315–316, *324*, 391–392, *398*
Mowrer, W. M., 130, *133*
Muenzinger, K. F., 174, *194*
Müller-Lyer, F., 403–404, 409
Munn, N. L., *74*, *90*, *113*, 123, *133*, 151, 160, *166–167*, *195*, *226*, 242, *254–255*, *284*, *319*, *326*, *360*, 366, *381*, 480, *488*, *604*
Murchison, C., *225*, *282*, *417*, *488–489*, *604*
Murphy, G., *24*, *304*, 572, *603*, *605*
Murphy, L. B., 572, *603*
Murray, H. A., 277, *283*, 581–582, 589, *604–605*
Mursell, J. L., *469*
McBride, K. E., 67, *73*
McCarthy, D., *38*, *90*
McClure, W. E., 585
McDougall, W., 273, *283*, 339, *359*
McElwee, E. W., 205, *225*
McFarland, R. A., 268, *283*
McGeoch, G. O., 183, *194*
McGeoch, J. A., 159, *166–167*, 177, 181, *194–195*, 200, *226*
McGraw, M. B., 86, *89–90*, 108–109, *113*, 279, *284*
McKinley, J. C., 576–577, *603*
McKinney, F. M., 377, *381–382*
McNemar, Q., *506*

Nafe, J. P., 479, *488–489*
Nagge, J. W., 234, *253*
Neet, C. C., 242, *254*
Neff, W. D., *489*
Nelson, M. J., 533, *543*
Newcomb, H., 174, *194*
Newcomb, T. M., *39*, 579, *603*, *605*
Newman, H. H., 100, *112*
Newman, J. R., 247
Nicholson, H. O., 586
Nissen, H. W., *38*
Nutt, R. H., 220, *226–227*
Nygaard, P. H., 504, *506*

Odbert, H. S., 571, *603*
Oden, M. H., 519, *543*
O'Kelly, L. I., 265, *282*, *326*
Omwake, K. T., *24*, *39*, 573–574, *603*
Otis, A. S., 537
Overstreet, H. A., 379

Padilla, S., 279, *284*

Painter, T. S., 93
Parker, G. H., 471
Parsons, J. H., *446*
Paschal, F. C., 386, *398*
Passey, G. E., 122, *132*
Paterson, D. G., 546
Patrick, C., 315, *324*
Pavlov, I. P., 118–119, 122, 124, 127–131, *132–134*, 318, *325*
Pearson, G. H. J., *382*
Pease, D. C., 93, *112*
Penfield, W., 64–66, *73*
Pfaffman, C., 476, *488–489*
Piaget, J., 245–246, *254*
Piéron, H., 386, *398*
Pillsbury, W. B., *399*
Pinel, P., 14–15
Pirenne, M. H., *446*
Plato, 3, 6
Poffenberger, A. T., 150, *568*
Pomeroy, W. B., 267, *282*
Poincaré, H., 246–247
Porteus, S. D., 145, 529–531, *543*
Postman, L., 167, *226–227*, *360*, 408, *416*, *446*, *469*, *489*
Pratt, K. C., *90*
Pressey, S. L., 574, *603*
Preston, G. H., 411, *416*, *605*
Preyer, W., 13
Pronko, N. H., 119
Prothro, E. T., 180
Purkinje, J. E., 421

Quigley, J. P., 262–263, *281*

Ranson, S. W., 57
Rapp, A., 338, *358*
Rawdon-Smith, A. F., *446*, *469*
Ray, M. B., *605*
Rayman, N. N., 391–392, *398*
Raynor, R., 334–335, *358*
Razran, G. H., 119, 122, 126, *133*
Reather, C. F., 76
Reed, R., 276, *283*
Renshaw, S., 480, *488*
Revesz, G., 45
Reymert, M. L., *360*
Ribble, M. A., 277, *283*, 338
Richards, I. A., 381
Richter, C. P., 261–268, *281*
Rigg, M. G., 345, *359*
Rignano, E., 238, *253–254*
Ritchie, B. F., 187–188, *195*
Roberts, K. E., 161, *166*
Robinson, E. E., *74*, *133*, *169*, *195*, *226*, *254*, *284*, *325*, *359*, *446*, *544*
Roethlisberger, F. J., 299, *303–304*
Rogers, C. R., 579–580, *603*, *605*
Root, A. R., 575, *603*
Rorschach, H., 580–582, *604*
Rosanoff, A. J., 291, *303*
Rosenzweig, S. F., 305, 308, 317–318, *324*, *326*
Rowley, J. B., 409, *416*
Ruch, F. L., *167*, 382
Ruckmick, C., *360*, *382*
Russell, B., 143, *165*
Rutherford, W., 461
Ryan, T. A., *255*

Sargent, S. S., *605*
Sassaman, W. H., 322, *325*
Scheerer, M., 243–244, *254*
Scheinfeld, A., 113
Schlosberg, H. A., 122, 200, *225*
Schneirla, R. C., *74*, *133*, *169*, *195*, *226*, *254*, *284*, *325*, *359*, *446*, *544*
Schoen, M., *469*
Schrickel, H. G., 589, *604*
Scolfield, E. H., 473, *488*
Scott, C. C., 263, *282*
Scott, W. W., 263, *282*
Scripture, E. W., 413, *416*
Sears, P. S., 293, *303*
Sears, R. R., 155, *166*, 313, *324*
Seashore, C. E., *469*, 562–563, *568*
Seashore, H., 344, 556
Seashore, R. H., *544*
Seguin, E., 18, 529
Shaffer, L. F., 126, *326*, *605*
Shagass, C., 122, *132*
Sheard, N. M., 275–276, *283*
Sheldon, W. H., 586–589, *604*
Sherif, M., 285–286, 293, *303–304*, 364, *381*
Sherman, I. C., 331, *358*
Sherman, M., 331, *358*, 522, *543*
Sherrington, C., 62–63, *73*
Shirley, M., 85, *90*
Shrodes, C., *304*
Shurrager, P. S., 119
Simon, T., 509, 542
Sinnott, E. W., 96
Skalet, M., 204–205, *225*
Skinner, B. F., 121, 189, *195*, *281*
Sleight, R. B., 565, *568*
Sleight, W. G., 159–160, *166*
Smith, G. M., *506*
Smith, J. R., 82, *89*
Smith, K. U., 242, *254*, 407, *416*
Smith, M. E., 88, *90*
Smith, S., 287, *303*
Snoddy, G. S., 157
Snow, W. B., 467, *469*
Snyder, L. H., *112*
Snygg, D., 307, *326*
Solomon, E. I., 262, *281*
Sorantin, E., 359
Spatz, D., 336, *358*
Spearman, C., 537–538, *543*
Spelt, D. K., 125, *133*
Spence, K. W., 153
Spragg, S. D., 291, *303*
Spranger, E., 574–575, *603*
Sprow, A. J., 10
Stagner, R., *605*
Starr, A. S., 205, *225*
Stein, S., 573
Steinberg, J. C., 467, *469*
Steiner, L. R., 21
Steining, B. R., 242, *254*
Stellar, E., *74*, *133*, *195*, 263, 268, *284*, 353, *359*, *469*, 471, *489*
Stern, W., 510
Stevens, S. S., 408, *416*, 459, 464, 467, 469, 586–589, *604*
Stewart, G. W., 469
Stewart, N., 549–550, *567*
Stoddard, G. D., *544*
Stolurow, L. M., 270
Stone, C. P., 106–107, *113*, 266, 269–270, 274–275, *282–284*
Stratton, G. M., 378, *381*
Street, R. A. F., 412
Strickland, B. A., 486, *489*
Strong, E. K., 299–300, *304*, 551–552
Stroud, J. B., 162, *166*
Sturman-Hulbe, M., 275, *283*
Supa, M., 31–33, *39*
Super, D. E., *568*
Swezy, D., 92
Symonds, P. M., 311, *324*, *326*, 582, *604*
Szondi, L., *604*

Taba, H., *605*
Taylor, D. W., 179, *194*
Taylor, G. A., 160, *166*
Taylor, J. H., 331, *358*
Teagarden, F. M., 267, *282*
Templeton, R. D., 263, *282*
Terman, L. M., 494, 502, 512–520, *544*
Teska, P. T., 180
Thompson, H., 110, *113*
Thompson, J., 334, *358*
Thompson, L., 149, *165*
Thompson, S. P., 405
Thorndike, E. L., 162, *166*, 174, *194–195*, 298, *303–304*
Thorndike, R. L., *568*, 573
Thouless, R. H., 408, *416*
Thurstone, L. L., 300–301, *304*, 538–541, *543*, 571, 581, *603–604*
Thurstone, T. G., 538–541, *543*
Tiffin, J., *506*, *568*
Tilney, F., 51, *73*
Tinker, M. A., 145, *506*
Tinklepaugh, O. L., 203, *225*
Titchener, E. B., *255*
Tolman, E. C., 173, 184–191, *194–195*, *304*
Tompkins, S. S., 373, *381–382*
Totten, E., 250, *254*
Trabue, M. R., *546*
Travis, R. C., 179, *194*
Tredgold, A. F., *521*
Trow, W. C., 155, *166*
Tryon, R. C., 102–103, *112*
Tsai, C. A., 201, *225*, 269, *283*
Tsang, Y. C., 262, *281*
Tucker, W. B., 586–587, *604*
Turner, C. D., 352, 584, 586, *604*

Uhling, H., 203, *225*
Ullman, J. R., 268, *283*
Underwood, B. J., *39*, *167*

Valentine, W. L., *24*, *39*, *74*, *134*, *167*, *195*, *227*, *255*, *284*, *297*, *303–304*, *326*, *360*, *382*, *417*, *544*, *568*, *605*
Van Dusen, F., 200, *225*
Van Gundy, J., *304*
Van Liere, E. J., 268, *283*
Van Tilborg, P. W., 200, *225*
Veltfort, H. R., *38*
Vernon, P. E., 574–575, *603*
Viteles, M. S., 557, *568*

Wald, G., 433, *445*
Wallas, G., 116, 246, *254–255*

Wallin, J. E. W., 521, *544*
Walter, A. A., 412, *416*
Ward, L. B., 159, *166*, 216, *226*
Warden, C. J., *73*, 140–141, *165*, 270–272, *283*, 409, *416*
Warner, L. H., *73*
Warren, H. C., 55, 228, *253*, *303*, 471, 476, 478, 525, *543*
Washburn, A. L., 262, *281*
Washburn, M. F., 4, 24
Washburn, R. W., 337, *358*
Watson, G., *338*, *359*
Watson, J. B., 86, *90*, 331, 334–335, *358*, 547, *567*, 594, *604*
Watson, R. I., *39*
Watts, J. W., 70, 251, *254*, 601, *605*
Weber, E. H., 413–414
Wechsler, D., 517–518, 531
Wegel, R. L., 456
Weinstein, B., 204–205, *225*
Weisenburg, T., 67, *73*
Weiss, E., 373, *381*
Weld, H. P., 53, *74*, *255*, *408*, *416*, *462*, *489*
Wellman, B. L., 522–523, *543–544*
Wendt, G. R., 122, *132*, 485
Wenzel, B. M., 473, *488*
Wertheimer, M., 239–240, *253–255*, 403, 406–407
Wesman, A. G., 556
Wever, E. G., 454, 459–460, 462–463, *469*
Wheeler, L. R., 522, *543*
Wheeler, R. H., 49, 73, *489*, 521–522, *543*
White, R. W., *326*, *604–605*
White, W. A., 599
Whiting, J. W. M., 293, *303*
Wickens, D. D., *24*, *39*, *74*, *134*, *167*, *195*, *227*, *255*, *284*, 297, *303–304*, *326*, *360*, *382*, *417*, *544*, *568*, *605*
Wiener, N., 58, *73*
Wiesner, B. P., 275–276, *283*
Wilkins, G. H., 263, *282*
Williams, R. E., 433, *445*
Willoughby, R. R., 378, *381*, 572, *603*
Winslow, C. N., 139, 404–405, *416*
Witmer, F. J., 130, *133*
Witmer, L., 18
Witty, P. A., *543*, 552
Wolf, H. G., 346–347, *359*, 373, *381*, 477, *488*
Wolf, S., 373, *381*, 477, *488*
Wolfe, J. B., 69, *73*
Wolff, W., 571, *603*
Wolfle, D. L., *544*
Wolfle, H. M., 125, *133*
Woodrow, H., 220, *226*
Woodworth, R. S., *24*, 111, *113*, *134*, 162, *166*, 181, 183–184, 186, *194–195*, 209, *225*, *227*, *255*, 292–293, *303*, 348, *359*, *382*, 388, 393, *398–399*, *417*, *446*, *469*, *489*, 523, *543–544*, 571, *603*
Worchel, P., 39
Wright, H. F., *90*, *113*, *324–325*
Wright, S. T. H., 179, *194*
Wundt, W., 8–11, 23
Wylie, H. H., 163, *166*

Yacorzynski, G. K., 191, *195*
Yerkes, R. M., 119, 231–233, *253*, 275, 508, *542–543*
Yoakum, C. S., 532, *543*
Young, K., *605*
Young, P. T., 174, 176, *194*, 264, *282*, *284*, *304*, 309–310, *324*, 352, *359–360*, 362–363, 381, *382*, 465, *469*
Young, T., 431–432
Yudin, H. C., 265, *282*

Zeigarnik, B., 216, *226*, 317–318, *324*
Zöllner, F., 405, 409
Zubin, J., *39*
Zuckerman, S., 143
Zwaademaker, H., 472

INDEX OF SUBJECTS

Ability, 548 (*see also* Intelligence and aptitude)
Abnormal, meanings of, 595
Abnormal psychology, 14–18
Absolute refractory period, 52
Absorption curve, 420–421
Abstracting, 241–246
Abscissa, 494
Accommodation, 430, 437
Achievement tests, 535
Achromatic vision, 418
Acquired b havior (*see* Habits)
Acquired motives, 285–302
Acquiring, 115–191 (*see* Learning)
Action current, 53, 241, 250
Action, initiation of, 319–322
Activity cage (drum), 261, 265
Activity cycles, 261–268
Acuity, olfactory, 472–473; tactual, 481–482; visual 433–434
Adaptation, cutaneous, 479; gustatory, 475; olfactory, 473–474; visual, 421, 432–433
Additive mixture, 426
Adjusted learning, 213
Adjustment, 10, 21, 136, 164
Adrenal glands, 266, 347–348, 584–585
Adrenalin, in emotion, 347–348
Aerial perspective, 441–442
Aesthesiometer, 481
Aesthetic preferences, 363–364
Affective processes, 329–330, 401 (*see also* Emotion)
Afferent neuron, 46
After-images, 428
Age, and conditioning, 125–126; effect on memory, 203, 205; effect on intelligence, 536–537
Aggression, 309
Airsickness, 485–486
Alexia, 67
All-or-nothing principle, 52–53
Allport-Vernon Study of Values, 574–575
Alpha rhythm, 59–60; conditioning of, 122
Ambivert, 575
Ameba, 43–45
Amnesia, 597
Amnion, 76
Amniotic fluid, 76
Amplitude, meaning of, 422
Ampullae, 483
Anaglyphs, 439
Anecdotal method, 11–12
Anesthesia, 597
Animal psychology, 11–12
Anger, control of, 374–375
Annoyances, 364–365
Anosmia, 169
Antagonism (sympathetic-parasympathetic), 55, 351–352
Anticipatory responses, 124
Anvil, 457
Anxiety, 373
Ape and child, 104–105
Aperture (film) colors, 419
Aperiodic vibration, 448
Aphasia, 67–68
Apparent motion (*see* Phi-phenomenon)
Appetite, 263–265
Aptitude, 545–567; and ability, 546–548; aviation, 559–562; defined, 545; distribution of, 546; factors in, 546; inborn and acquired, 546–548; intelligence and, 548–551; interest and, 551–553; mechanical, 553–558; medical, 562; musical, 562–563; scholastic, 548–549
Aqueous humor, 429
Arapesh, 287
Army Alpha test, 531–532
Army Beta test, 531, 534–535
Army General Classification Test (A.G.C.T.), 532, 549
Ascending paths of cord, 48, 54
Aspiration, 292–293
Assertiveness, 287–289
Association, and complexes, 372; as neural process, 66–70; in recall, 221–222; in reasoning, 229–230, 237–240
Association areas, 50, 66–70
Association neuron, 46
Association paths, 60
Astigmatism, 436
Attending, 385–398; aspects of, 386–393; central adjustments in, 390–392; and clearness of perception, 392–393; determiners of, 395–397; fluctuations in, 393–395; habitual, 394; involuntary, 394; role in memory, 221; muscle tensions in, 389–390; nature of, 385–386; perceiving and, 397; postural adjustment in, 388–389; receptor adjustments in, 387–388; voluntary, 394
Attitude scale, 300–301
Attitudes, development of, 130; and interests, 299–300; methods of measuring social, 300–301; unconscious basis of, 297
Audiogenic seizures, 319
Audition, 65 (*see also* Hearing)
Auditory canal, 457
Auditory localization, 463–467
Auditory perspective, 466–467
Auditory nerve, 457
Auditory nerve potential, 460
Aural harmonics, 460
Autocorrectivism, 310
Autogenous development, 107
Autonomic nervous system, 54–56, 351–352
Autonomy, behavioral, 257
Aversions, 265
Aviation psychology, 153, 555, 559–561
Axon, 46

Babbling, 87
Baby tests, 203–204, 510–512
Backward conditioning, 125
Bar graph, 494
Barriers, 305–306
Basal age, 516
Basilar membrane, 458
Beats, 454
Bechterev's conditioning technique, 119–120
Behavior, defined, 1, 19–21; at birth and after, 83–88; in unborn, 80–83; tests, 510–512, 577–579
Bel, 450–451
Belittling others, 311–312
Beta waves, 62
Bimodal curve, 495
Bilateral transfer, 156–157
Binet-Simon tests, 508–509
Binocular cues, 436–440
Biographical method, 35–36
Bipolar cells, 431, 434
Blaming others, 311–312
Blast injection technique, 473
Blind, 31–33, 168
Blind spot, 428
Brain; electrical stimulation of, 63–66; in emotion, 351–356; evolution of, 48–51; fetal, 78–79; and learning process, 169–172; localization of functions in, 7, 63–69; and thinking, 249–251; visual functions of, 435–436; (*see also* Cerebral cortex)
Brain injuries, effect of on learning, 169–172; effects on sensory, motor and associational processes, 63–70, 244; recovery from, 65–68
Brain stem, 56–57, 63
Brain waves, 59–63, 82 (*see also* Electroencephalograms)
Brain weight-spinal cord weight ratios, 50
Brain weight-body weight ratios, 48–49
Brightness, 418–420; constancy of, 408–422; relational discrimination of, 408–409

Cafeteria feeding, 263
Capacity, concept of innate, 524–526, 546–548
Card-sorting experiment, 163
Case history method, 35–36
Catatonic schizophrenia, 600–601
Cathode-ray oscilloscope, 451–452
Cell body, 46
Centralization, 47–48
Central nerve ring, 47
Central nervous adjustment, 390–392
Central nervous system, 47, 53–54 (*see also* Brain, Spinal cord, and Cerebral cortex)
Central tendency, measures of, 496
Central theory of thinking, 249–251
Cephalocaudal sequence, 84
Cerebellum, 7, 56, 78–79
Cerebral cortex, 48, 58–70; associa-

tive functions of, 66–70; in color vision, 436; and conditioning, 119; in emotion, 353; growth of in fetus, 78–79; and hearing, 459, 461; in initiation of action, 322; and the learning process, 169–172; localization of functions in, 63–70, 171–172; motor functions of, 65–66; sensory functions of, 63–65; role of in thinking, 249–251; and visual functions, 435–436
Cerebral hemispheres, 56
Cerebral lesions, 169–172
Cerebrotonia, 588
Cerebrum, 49–51, 56, 78–79 (*see also* Cerebral cortex)
Certification, 21–22
Character, 570
Child psychology, 13 (*see also* Children)
Children, cafeteria feeding of, 263–264; development of concepts in, 241–246; conditioning of, 124–126, 129; development of conscience in, 321; development of, 75–112; effects of frustrating, 316–317, 375; growth of emotions in, 331–336; gifted, 519; intelligence of, 508–517; learning in, 147–148; maturation of behavior in, 102–105, 107–110; memory in, 203–205; development of perception in, 410; performance tests for, 510–512, 529–530; development of personality in, 583, 589–594; problem solving by, 147; development of reasoning in, 230–235; beginnings of social interaction in, 591
Choice-point, 185
Choice, topological representation of, 307
Choroid coat, 429
Chromatic vision, 418
Chromosomes, 92–93
Chronological age (C.A.), 509
Chronoscope, 11, 270, 555
Cilia, 45
Ciliary muscle, 429–430
Circulatory changes in emotion, 345–347
Circumvallate papillae, 475
Class intervals, 494
Classical conditioning, 122–123
Claustrophobia, 376
Clearness in attending, 392–393
Clinical procedure, 35–36
Clinical psychology, 17–18, 35–36
Cochlea, 457–458
Cochlear response (microphonic), 459
Coefficient of correlation (r), 503–504
Coenotropes, 286–287
Cognitive maps, 186–187
Cold spots, 477
Color blindness, 426
Color mixture, 423–426
Color preferences, 362
Color solid, 423
Color weakness and blindness, 426
Color vision, 418–429; theories of, 431–432
Color zones, 427–428
Comanche, 288–289
Combination tones, 455
Combining past experiences, 229–231
Common chemical sense, 470
Common social motives, 286–289
Compensation, 310
Compensatory reactions, 310–318
Complementary colors, 424–425
Complex, 372
Complex learning processes (*see* Reasoning)
Complex co-ordinator, 561
Complex indicators, 372
Compound eye, 44
Compulsions, 597
Conception, 91
Concepts, in animals, 242; in children, 244–246; formation of, 241; methods of teaching, 244–246
Condensations, 448
Conditioning, age and, 125–126; backward, 125; classical compared with instrumental, 122–123; defined, 117–118; direction of, 123; of fear responses, 334–335; fetal, 125–126; generalized and differential, 126–128; higher order, 129; and learning in general, 130; negative, 123; sequences and time relations in, 124–125; significance of in everyday life, 129–131; social, 285–289; techniques, 118–125; voluntary control, 322
Conditioned response, 117–134; extinction of, 128; relation to unconditioned response, 123–124 (*see also* Conditioning)
Conditioned stimulus, 117–118
Cones, 430–432
Conflict, 305–322; of motives, 306–309; reactions to, 309–322; relation to "will power," 319–322; sources of, 305–306; topological representation of, 307
Conscience, 320–321
Conscious experience, 9, 20–21; in dangerous situations, 378; in emotion, 329–330
Consciousness, 1, 9, 19–21
Consolidation, 181
Constancy phenomena, 408
Constant factors, 30
Context, 409–410
Contiguity, 185
Control, 28–34, 157
Convergence, 437
Cornea, 429
Corpus callosum, 56
Corpus striatum, 56
Correlation, 499–504
Corti, organ of, 458–459
Cortical (*see* Cerebral cortex)
Cortical localization, 63–69
Cortical rhythms, 59–62, 82
Cortico-thalamic paths, 355
Co-twin control, 110
Cranial nerves, 54, 435, 457, 471, 476
Crawling, 85
Creative thinking, 246–249
Creeping, 85
Cretinism, 586
Crista, 483–484
Criteria, in evaluation of tests, 559
Critical flicker frequency (c.f.f.), 434–435
Critical ratio (C.R.), 499
Critical (cut-off) score, 564
Cross-education, 156–157
Crowd behavior, 19
Crying, 82
Culture, and emotional expression, 334; and motivation, 285–289; and sex drive, 271
Cutaneous sensitivity, 63–64, 476–482
Cytoplasm, 92–93, 97

Danger, reactions to, 377–378
Dark adaptation, 432–433
Day-dreaming, 229
Decibel, 450–451
Delayed matching in terms of a sample, 204–205
Delayed reaction experiment, 68–69, 201–204
Delusions, 238, 598–601
Dementia praecox (*see* Schizophrenia)
Dendrites, 46
Density, auditory, 447
Dependent variable, 29–30
Depression, 600
Deprivation, 261
Depth perception, 436–443
Depth psychology, 571
Descending paths of cord, 48
Determiners, in attending, 395–397
Determining tendencies (*see* Set)
Deterrents, 260
Detour problem, 141–142, 147
Development, autogenous, 107; of brain, 77–79; of concepts, 241–242; of conscience, 320–321; of emotion, 331–340; of emotional control, 374–379; effect of heredity and environment on, 98–100, 524–526; of intelligence, 518–526; maturation and, 102–111; of motives, 285–290; motor, 79–87; of nervous system, 77–79; of perception, 410–411; of personality, 583–595; of skill, 135–167; of social behavior, 591; of speech functions, 86–88
Developmental psychology (*see* Genetic psychology)
Dexterity, development of in child, 84–86; evolution of motor, 45; tests of, 554–555, 558
Dianetics, 598
Difference tones, 455
Differential forgetting, 181
Differential threshold, 413–414
Differentiation, behavioral, 84; cellular, 76; conditioned, 126–128; of emotions, 331–336
Direct conditioning, 377
Direction set in reasoning, 237–240
Direction of conditioning, 123
Discrimination, apparatus, 137; conditioned, 128; learning, 136–138; of movement 407; in newborn, 83; in psychophysics, 413–414; relational, 408–409

Dissociation, 597
Dissociation by varying concomitants, 245
Distribution of effort in learning, 178–182; as a memory aid, 212–213, 222–223
Doctrine of specific nerve energies, 51–52
Dominance, hereditary, 96
Dorsal columns of cord, 23; roots, 23
Double-alternation problem, 233–235
Dramamine, 486
Dreams, 16–17, 229, 580
Drives, 260–279; methods of studying, 261–262, 269–272; relation to instinct, 273–275; socialization of, 285–289; relative strength of, 269–272
Drugs, experiments on, 33
Drug addiction, 290–291
Dual personality, 590
Dysrhythmia, of E.E.G.'s, 61

Dual personality, 590

Ear, mechanism of, 457–458
Eating, rhythms of, 261; social influence on, 265
Economy of learning, 178–184
Ectomorphy, 587–588
Educational psychology, 10–11
Effectors, evolution of, 45; growth of in fetus, 79–80; role in thinking, 249–251; structure of, 482, 584
Efferent neuron, 46
Ego-defensive reactions, 310, 317
Ego-involvement, 285–286, 317
Eidetic imagery, 209–210
Electric-shock therapy, 601
Electrical potentials, 241, 250 (*see* Action currents)
Electrocardiogram, 349
Electrodermal changes, conditioned, 127; in emotion, 346, 348–349, 371–372
Electroencephalogram (E.E.G.), 59–63, 82
Electromagnetic radiation, 420
Embryo, 75–79
Emotion, 327–380; adrenal discharge in, 347–348; classification of infant, 332; as conscious experience, 327–330, 345; control of, 374–379; development of, 331–340; as causative factor in disease, 373–374; emergency function of, 327; expressions of, 333–334, 339, 341–345, 365–371; and forgetting, 219–220; judgments of infant, 331–332; learning as basis of, 332–336; maturation of, 332–334; neural mechanisms in, 57, 351–353; physiological concomitants of, 345–353; theories of, 353–356
Emotional complex, 372–373
Emotional maturity, 378–379, 572
Encapsulated end organs, 478
End brush, 46
Endocrine glands, 80, 266, 347–348; illustrated, 584
Endolymph, 483
Endomorphy, 587
Engineering design, 564–566
Engram, 199
Enuresis, 130
Environment, effect of on intelligence, 98–102, 524–526; kinds of, 91–92, 97–98; and personality, 589–595; social, 19
Epilepsy, 61–62
Equilibrium (*see* Static sense)
Estrin, 266
Eustachian tube, 457
Excitability, 43–45
Expectancy, 189
Experience, emotional, 329–330; psychology as a science of, 8–10, 20
Experimental aesthetics, 363–364
Experimental extinction, 128, 130
Experimental introspection, 9
Experimental method, 7–9, 27–34
Experimental neuroses, 318–319
Experimental psychology, 8–13, 27–34
Exploratory drive, 272
External ear, 457
External environment, 98–100
External response, 20, 29
Extinction, experimental, 128, 130
Extraversion, 575
Eye, evolution of, 44–45; structures of illustrated, 429, 431, 434–435
Eye-movements, in attending, 388–389; photographing, 388; postrotational, 484; in thinking, 250
Eyes versus mouth in judgments of emotional expression, 367–369

Face validity, 562
"Facial" vision, 31–33
Facilitation, neural, 47
Factor analysis, 537–541
Factors in intelligence, 537–541
Factors S.T.D.C.R., 575
False recognition, 211
Fantasy, 229, 311
Far-sightedness, 430
Fear, 345, 375–378
Feebleminded, 17–18, 520–521
Feed-back, 57–58
Feeling, 329–330, 361–365
Fertilization, 75, 91
Fetal conditioning, 125–126
Fetal period, 80–83
Fetus, 75–83; behavior of, 80–83
Fiber tracts, 48, 54
Figure and ground, 394
Film (aperture) colors, 419
Finger-thumb opposition, evolution of, 45; in prehension, 86–87
Fissure of Rolando, 59
Fissure of Sylvius, 59
Fixation resulting from frustration, 319
Flicker, 434–435
Flight of ideas, 600
Flying, acquisition of, 153; aptitude, 553, 558–561
Food preferences, 264
Force of habit, 294
Fore brain, 77
Forgetting, 197–198; 214–220; differential, 181; emotion and, 219–220; and activity, 217–219; and type of material, 214–215; overlearning and, 215–216; and original learning, 211–215; reasons for, 217–220; as retroactive inhibition, 219; effect of sleep on, 217
Formal discipline, doctrine of, 162
Formboard, 18, 529
Forms, recall of, 207–208
Fovea, 429
Fraternal twins, 94
Free association of ideas, 228, 580
Free nerve endings, 478
Frequency distribution, 493
Frequency polygon, 494
Frequency principle of nerve activity, 52–53, 461
Frequency theory of audition, 461
Frigidity, 267
Frontal lobes, 59, 68–70, 171–172, 251
Frustration, 305–322; defined, 305
Frustration tolerance, 308
Fugue, 597
Functional autonomy, 293–294
Functional disorders, 14, 596–601
Functional psychology, 10
Fundamental tone, 452
Fungiform papillae, 475–476

Galton whistle, 449–450
Galvanic skin response (G.S.R.), conditioning of, 127; in emotion, 348–349
Ganglia, 48, 55
Ganglion cell, of retina, 431
Gastrointestinal disorders, 373–374
General intelligence (g), 537–538
General psychology defined, 22
Generalization, conditioned, 126–128; in concept formation, 240–242
Generalized responses, in conditioning, 126–127; in babies, 84; in locomotor development, 85; in prehension, 86
Generalizing, defined, 241; experiments which involve, 240–242
Genes, 93
Genetic method, 11–13, 26
Genetic psychology, 43–51, 75–112, 82, 229–235, 536–537, 583–595
Geniuses, 517, 519–520
Gestures, as language, 87
Gestalt psychology, 403–409
Gifted children, 519–520
Glands, duct, 80; ductless, 80 (*see* Endocrines)
Glands and personality, 584–586 (*see also* Endocrine glands)
Goal objects, 260
Goal orientation, 186–189
Goals, 291–292
Gonads, 266, 584–585
Graphology, 22
Grasping, conditioned, 121, 126; origin of reflex, 81; in prehension, 86
Gray matter, 54
Gregariousness, 286
Group behavior, 19
Group tests, 531–535

Guidance, individual vs. group, 563–564
Gustation (*see* Taste)
Gynephobia, 376

Habits, 103, 277–279; of attending, 395–396; elimination of, 130; formation of (*see* Learning); man a creature of, 277–279; persistence of, 293–294
Habit hierarchies, 152; as basis of plateaus, 155
Habit interference, 162–163; as factor in plateaus, 155
Habit strength, 186
Hair cells (of Corti), 458
Hallucinations, 403
Hand, evolution of, 45; growth of in embryo, 80
Handedness, 67, 86
Harmonics, 452
Hawthorne experiment, 299
Healy puzzle box, 146
Hearing, 447–468; role in learning, 169; physiological bases of, 456–463; range of human, 449–450; theories of, 460–463
Hebephrenic schizophrenia, 600
Helicotrema, 458
Helmholtz theory, 460–461
Hereditary defects, 98
Heredity, 91–97; and environment, 98–111; and intelligence, 101–102, 524–526; and personality, 100; transmission of, 92–97
Higher-order conditioning, 129
Hind brain, 77
Histogram, 494
Home environment, 589–593
Homeostasis, 259–260, 310
Honesty, 578–579
Hopi Indians, 107–108, 287
Hormones, 584 (*see also* Endocrine glands)
Hue, 419
Hull's theory, 184–191
Human nature, 18
Hunger, 261–265, 272; and blood chemistry, 262; drives, 263; in everyday life, 264–265; as a factor in learning, 135–136; as a motive, 261–265; as organic sensitivity, 486
Hunger pangs, 261
Hybrids, 96
Hydrocephalic, 521
Hypnosis, 16; animal, 217; as central adjustment, 391; and conditioning, 122; phenomena of, 295–297; unconscious motivation in, 295–297
Hypothalamic (thalamic) theory, 353, 355–356
Hypothalamus, 56–57, 355–356
Hypotheses, 236–237
Hysteria, 16, 597

Ideas, rational elaboration of, 237 (*see* Symbolic processes)
Identical twins, 94, 110
Identification, 311
Idiots, 517, 521
Illusions, 403–408
Imagery, eidetic, 209–210; as a factor in memory, 222; in thinking, 240
Imbeciles, 517
Imitation, 140–141, 148–150
Immobility, tonic, 217
Implicit trial-and-error, 147; in danger, 377–378 (*see also* Reasoning)
Impotence, sexual, 267
Incentives, 260, 297–299
Incidental learning, 172, 177
Independent variable, 29
Indian, 287–289, 522
Individual, beginning of psychological interest in, 14–18
Individual differences, 10–11, 14–18, 491–603; in aptitudes, 545–546; in identical twins, 100–101; in intelligence, 507–542, 548–550; in maze learning, 101–102; in personality, 569–603; in sex drive, 267; significance of, 491–492; statistical treatment of, 493–506
Individual tests, 508–518
Inferences, 236–237
Information, as a factor in skill, 135–136, 191 (*see also* Latent learning)
Inheritance (*see* Heredity)
Infra red, 418–419
Inhibiting, 317
Inhibition, neural, 47; cortical, 57; retroactive, 219
Initiation of action, 321–322
Innate (inborn) capacity, 546
Inner control, 257–258
Inner ear, 457
Insanity, 14–15 (*see also* Psychoses)
Insight, 141–144, 146–147, 154; and creative thinking, 248; and forgetting, 214
Inspiration in thinking, 248
Instincts, defined, 50–51, 115; relation to drives, 272–274; question of human, 272–279
Instructional sets, 412
Instrumental conditioning, 122–123
Insulin therapy, 601
Integration, 16
Integrative functions of cerebral cortex, 47–51
Intelligence, 507–542, 548–551; age and, 536–537; and aptitudes, 548–551; and the brain, 48–51; concept of, 507–508; constancy of, 518–524; defective, 520–521; defined, 507; distribution of, 494, 532, 549; early tests of, 508–509; education limited by, 520, 526; evolution of, 508; factors in, 537–541; growth of, 536–537; effect of heredity and environment upon, 100–102, 524–526; and nursery school attendance, 522–523; quotient (I.Q.), 509–510; racial differences in, 522; social, 573–574; tests of, 508–518, 529–536, 538–541; thyroid functions and, 521–522; upper levels of, 517, 519–520; values of measuring, 526–528
Intelligence quotient (I.Q.), 509–510; constancy of, 520–521; determination of, 516; effect of heredity and environment upon, 100–102, 524–526; meaning of, 516–517; value of determining, 526–528
Intensity, as determiner of attention, 395
Intention, as factor in initiation of action, 322
Intention to learn, 220–221
Intercellular environment, 97
Interconnecting circuits, 57–58
Interest inventory, 551–553
Interests, aptitudes and, 551–553; compared with attitudes, 299–300
Internal responses, 20, 29
Internal stimuli, 28
Interpolated activity, 217–219
Interposition, 440–441
Intervening variables, 184–187
Interviews, 579–580
Intracellular environment, 97
Introspection, 9; in research on emotion, 329–330
Introversion, 575
Invagination of cortex, 49–50, 79
Involuntary attending, 394
Involuntary responses, conditioning of, 122
Ions, 53
Iris, 429–430
Irradiation, in conditioning, 128
Ishihara Test, 426
Ivanov-Smolensky's conditioning technique, 121

James-Lange theory, 353–356
Job analysis, 557
Johnny and Jimmy, 108–110
Judging emotional expressions, 365–370
Just noticeable differences (j.n.d.'s), 413–414

Kappa waves, 60, 62
Kinesthesis, 58, 482–483; role of in learning, 169
Knee-jerk, conditioning of, 122
Knowledge, as factor in learning, 184–191
Knowledge of results, 175–176
Krause end bulbs, 478–479
Kuder preference record, 552–553
Kymograph, 261–262, 478–479

Language, 45, 67–68; development of in child, 86–88, 150–151; role of conditioning in development of, 129; role of in initiation of action, 322; as factor in recall, 204; and thought, 240–241
Latency, 122
Latent learning, 190–191
Learning, 10, 12, 115–192; adjusted, 213; animal, 136–144; animal compared with human, 144–146; role of brain in, 48–51, 169–172; conditions of, 168–193; curves of, 153–156; economical methods of, 178–184; in emotional development, 332–336; heredity and, 101–

103; human, 144–163; to imitate, 141; by imitating, 140–141; incidental, 177; insight in, 141–144, 146–150; knowledge of results and, 175–176; levels of complexity in, 152; as limited by maturation, 108–110; compared with maturational development, 110–111; maze, 138–139, 144–146; role of motivation in, 145, 172–178; passive vs. intentional, 177; as influenced by praise and reproof, 174–175; problem box, 139–142, 146; punishment and, 174; role of rewards in, 172–174; rivalry and recognition as motivators of, 176–177; sensory contributions to, 168–169; to speak, 150–151; theories of, 184–191; transfer of, 156–165; verbal, 150–151
Learning ability, inheritance of, 101–102
Lens, 429
Levels of aspiration, 292–293
Levels of complexity in habit formation, 152
Licensed psychologist, 21–22
Lie-detection, 370–372
Life goals, 291–293
Life history, as factor in motivation, 285
Light adaptation, 422
Lightness, 419
Linear perspective, 440
Linguistic communication, 87–88, 116
Lobes, 59–60
Lobotomy, 69–70 (*see also* Psychosurgery)
Local signs, 481
Localization, auditory, 31–33, 463–467
Localization, cortical, 63–69
Localization, tactual-kinesthetic, 480–481
Locomotion, development of in child, 84–86; evolution of, 45; mechanics of, 84–85; sequence of, 85
Loudness, 447, 450–451
Love, 327, 330, 338
Luminosity curve, 421

Malaria therapy, 598
Malingering, 598
Mania, 600
Manic-depressive psychosis, 599–600
Manipulation, 45, 86–87
Masking, auditory, 456
Mass action, in behavior, 84–86; of cerebral cortex, 169–172; in emotional behavior of newborn, 331
Massed learning, 178–182, 212–213
Mastery motive, 287
Maternal drive, 275–277
Mating, 274–275
Maturation, defined, 102; experiments on, 102–111; as a factor in emotional development, 332–334; in relation to instinct, 277–279; compared with learning, 110–111; as a limiting factor in the learning process, 108–110
Maze learning, in animals, 138–139; human, 144–146; human and animal compared, 144; inheritance of capacity, 101–103; retention of, 201; spatial compared with temporal, 233
Mazes illustrated, 138, 145, 188, 233
Mean, 496; standard error of, 498–499
Meaning, 129, 184, 409
Mechanical aptitudes, 553–556
Mechanical comprehension test, 556
Median, 496
Medical aptitude, 561–562
Medical psychology, 14–18, 595–601
Medulla, 56
Meissner's corpuscles, 478
Membrane theory of nerve conduction, 53
Memory, 44, 151–152, 197–225; role of brain in, 44; evidences of, 199–205; history of research on, 11; and interpolated activity, 217–220; and original learning, 211–214; recall, 201–211; recognition, 204–205, 211; and speed of learning, 213–214; role of stimuli in, 210–211; training, 220–223
Memory drum illustrated, 152
Memory span, 205
Memory trace, 197, 199
Menopause, 266–267
Mental age (M.A.), 509
Mental development (*see* Development)
Mental hygiene, 15, 600
Mental philosophy, 2–6
Mental set (*see* Set)
Mental tests, 10–11
Merrill-Palmer Scale, 530
Mesomorphy, 587–588
Metrazol therapy, 598
Microcephalic, 521
Midbrain, 56, 77
Millimicron, 420
Mind, 1–6
Minimal cues (*see* Reduced cues)
Minnesota Assembly Test, 554
Minnesota Multiphasic Personality Inventory (M.M.P.I.), 576–577
Minnesota paper formboard, 556
Mirror drawing, 157
Mode, 496
Monetary incentives, 298–299; role of in learning, 173–174
Monochromatic light, 420
Monocular cues, 437
Morale, 299
Moron, 517, 520
Morphine addiction, 290–291
Motion picture, principle of, 406; teaching with, 149
Motion sickness, 485–486
Motivation, 172–178, 257–323; common social, 286–289; as factor in conditioning, 121–123; defined, 257–258; and distributed learning, 181; excretory, 268; hunger, 261–265; industrial, 155, 299; in learning process, 172–178; maternal, 272, 275–278; and memory, 220–221; oxygen, 268; personal, 289–324; and personality, 590, 595; physiological, 259–281; as basis of plateaus, 155; in reasoning, 235–236; sexual, 265–267, 269–272, 274–275; temperature, 269; thirst, 267–268, 271; unconscious, 294–297
Motives, 260; acquired, 285–302; social, 176–177, 285–289
Motor area, 65–66
Motor development, in evolution, 45; in fetus, 79–83; in infant, 83–88; effect of restricted activity upon, 105–110
Motor end plate, 482
Motor neuron, 46
Motor (muscular) set, 202
Motor speech area, 67
Müller-Lyer illusion, 403–405
Multimodal distribution, 495
Multiple-choice problem, 231–233
Multiple personality, 590, 597
Mundugumor, 288
Muscles, 482 (*see* Effectors)
Muscle tensions, 250, 389–390
Music, emotion in, 344–345
Musical aptitudes, 562–563

Nail biting, 130–131
Narratives, recall of, 206–207
Naturalistic observation, 26–27, 31
Nausea, 485–486
Near sightedness, 430
Needs, 259, 268, 290
Negative conditioning, 123
Negative correlation, 501
Negative transfer, 162–163
Nerve, 47
Nerve fiber, 46
Nerve impulse, 51–53
Nerve-net system, 46
Nerve ring, 47
Nervous system, 46–72; development of, 77–80; elementary forms of, 43–51; growth of as affected by activity, 110–111; and instinctive behavior, 278–279; and the learning process, 43–44, 169–172; and personality, 589, 599; structures and functions of human, 49–70, 77–80
Nest-building, 275–276
Neural circuits, 48
Neural constitution, 584
Neural evolution, 43–51
Neural bulbs, 77; groove, 77; tube, 77
Neural inhibition and facilitation, 46–47
Neural mechanisms in emotion, 351–356
Neural records, 44, 51, 199
Neurasthenia, 596
Neurogram, 199
Neuron, 46
Neuroses, 15–17 (*see* Psychoneuroses)
Neurotics, 15–17, 596–598
Neutral gray, 423

Newborn, sensitivity and behavior of, 83–84
"New brain," 50
Night blindness, 433
Noise, 448–449
Nondirective (client-centered) interview therapy, 579–580
Nonsense syllables, use of in research, 151; forgetting of as compared with meaningful material, 214–215
Normal personality, meaning of, 595
Normal probability curve, 495
Northwestern Intelligence (baby) Tests, 510–512
Novel responses, learning of, 189–190
Nucleus, 92
Nursery school, 522–523
Nymphomania, 267
Nystagmus, 484

Object Sorting Test, 243
Objective approach, 20
Observation, naturalistic, 26–27
Obstacles, perception of, 31–33
Obstruction method of studying drives, 270–272
Occipital lobe, 59
Occupational therapy, 600
Octaves, 4.2
Ocular nystagmus, 484
Odors, classification of, 471
"Old brain," 50
Olfaction, 470–475; role of in learning, 169
Olfactometer, 472
Olfactorium, 474
Olfactory bulbs, 49–50, 471
Olfactory epithelium, 471
Only children, 592
Optic chiasma, 435
Optic cup, evolution of, 44
Optic nerve, 79, 429, 435
Optic radiation, 60, 435
Ordinate, 494
Organ of Corti, 458–459
Organic (structural) disorders, 14, 598–599
Organic sensitivity, 486
Organism, control of, 28–29; early interest in, 4–5; growth of, 75–112; structures and functions of, 41–72
Oscillograph, 448
Ossicles of ear, 457
Otoliths, 484
Oval window, 457–458
Overcompensation, 312–313
Overlearning, 215–216
Overtones, 452
Ovum, 75, 92
Oxygen want, 268

Pacinian corpuscles, 478
Pain, 64, 477–479
Pain spots, 477
Paired associates, 205–206
Paired comparison, 362
Paralysis, following brain injury, 65–66
Paranoid schizophrenia, 601
Parasympathetic system, 55, 351–352
Paresis, 598–599
Parietal lobe, 59
Part learning, 183–184
Partials, 452–453
Passive vs. intentional learning, 177–178
Pavlov's conditioning technique, 118–119
Pencil-and-paper personality tests, 573–577
Peptic ulcer, 573
Perceiving, 397, 400–416; affective processes in, 400–401; analysis of, 400–402; and attending, 397; by the blind, 31–33; constancy of, 408; context and, 409; development of, 410–411; differences in, 410–411; past experience in, 410; examples of primitive, 403–409; role of receptor processes in, 400–401; reduced cues in, 412; set in, 411–412; role of symbolic processes in, 401
Percentile rank, 535
Perception, as factor in learning, 135–136, 184–190 (*see also* Discrimination, Insight, Perceiving)
Perceptual constancy, 408
Performance tests, 528–531
Perimeter, 427
Periodic vibration, 448
Peripheral-central theory of thinking, 249–250
Peripheral nervous system, 54
Peripheral retina, 427–428
Perseveration, 181
Persona, 570
Personal defects, 305, 309
Personal motives, 285, 289–302
Personality, 569–603; abnormal, 595–601; biological bases of, 69–70, 584–589; and the brain, 69–70, 589, 598–599; changing one's, 594; concept of, 14; defined, 569–571; development of, 583–595; environmental bases of, 589–595; factor analysis of, 571; glandular bases of, 584–586; effect of home environment upon, 591–593; methods of investigating, 572–583; in newborn, 583–584; neural bases of, 68–70, 589, 598–599; normal and abnormal, 595–601; onliness and, 592; and physique, 586–589; profile, 577; situational influences in, 589–595; tests of, 572–583; traits, 571; types, 575, 586–589
Perversions, 267
Phase, 454
Philosophy, 1–6
Phi-phenomenon, 406–408
Phobias, 130
Phonetic alphabet, 87
Photochemical reactions, 432–433
Photosensitivity (*see* Vision)
Phrenology, 22
Physics, 7–8
Physiognomy, 22
Physiological aspects of emotion, 345–353
Physiological cues in space perception, 437–440
Physiological drives, 259–281
Physiological limit in learning, 155
Physiology, 7
Physique and temperament, 586–589
Pigment spot eye, 44
Pineal gland, 584
Pitch, 447–449
Pituitary gland, 56, 266, 584–586
Place learning, 184–191
Place theory of pitch, 460–461
Plateaus, 155–156
Pleasantness, 329–330, 361–364
Plethysmograph, 346
Pneumograph, 346
Polarized membrane, 53
Pons, 56
Positive correlation, 501–502
Post-ganglionic fibers, 352
Post-hypnotic suggestion, 295–297
Postnatal environment, 99–100
Postural reactions in emotion, 344, 369
Post-rotational nystagmus, 484
Postural set, 385–386, 388–389
Practice distinguished from training, 150
Praise, as motivator of learning, 174–175
Precocity, 519–520
Preferences, 264, 361–364
Prefrontal lobotomy, 69–70, 251
Prehension, 86–87
Prejudices, 300
Preparation stage in creative thinking, 246–248
Preperceptive sets, 386
Prenatal development, 75–83
Prenatal environments, 97–99
Pressey X–O test, 574
Pressure spots, 477
Prestige, as factor in preferences, 363–364
Primary colors, 431
Primary odors, 471
Primary reinforcement, 186
Primary skin senses, 477
Primary tastes, 475
Primitive organization, perceptual, 403–408
Principles, as factors in transfer, 161–162
Probability curve, 495
Probable error (P.E.), 497–498
Problem box, illustrated, 139–142, 146
Problem solving, by animals, 139–143; direction factor in, 237–240; human, 146–147; reasoning in, 228–240
Product-moment correlation (r), 503
Profiles, 553, 563, 577
Projection, 313–314; neural, 59–60
Projective methods, 580–583
Prolactin, 275
Protective reflex, 119–120, 124
Protoplasmic conduction, 43–44
Pseudo-affective reaction, 353
Pseudophone, 465
Pseudopsychology, 21–22
Psychasthenia, 597
Psyche, 1–5, 19–20

Psychiatry, beginnings of, 14–15; and conditioned responses, 130
Psychoanalysis, 16–17, 580
Psychogalvanic response, conditioned, 127; in emotion, 346–349, 370
Psychogalvanometer, 346, 348, 370
Psychograph, 577
Psychological abstracts, 10
Psychological clinic, 18
Psychological cues, in tridimensional vision, 439–442
Psychology, abnormal, 14–18; aims of, 21–22; animal, 11–12; child, 13; defined, 19–21; educational, 11; experimental, 8–13; history of, 1–23; methods of, 25–38; social, 18–19
Psychomotor tests, 153, 554–555, 558
Psychoneuroses, 15–17, 596–598
Psychophysics, 413–414
Psychoses, 14–15, 598–601
Psychosomatic medicine, 373
Psychosurgery, 69–70, 251, 601
Psychotic, 14
Puberty praecox, 585
Pugnacity, 288–289
Punishment, in instrumental conditioning, 119–120, 122–123; in learning process, 174
Pupil, optic, 430
Pupillary response, conditioning of, 122
Purkinje phenomenon, 421
Pursuitmeter, 153
Pyramidal cells, 59, 65; tracts, 59, 60, 65

Quadruplets, 94

r, 503
Racial intelligence, 522
Racial preferences (color), 362
Radiant energy, 420
Rage, 331
Range, 496–497
Range of hearing, 449–450
Rank difference correlation, ρ, 503
Rank order, 503
Rarefaction, 448
Rate of manipulation test, 180
Rating method, 572
Rating scale, 572
Rational elaboration of ideas, 237
Rationalizing, 313–315
Reaction mechanisms, 43–73, 75–112
Reaction time, 10–11, 558–559
Reactions to danger, 377–378
Reactions to frustration, 309–319
Reasoning, 228–253; in animals, 229–235; and the brain, 68–70; in children, 230–231, 234–235; creative, 246–249; description of process, 228, 235–240; development of, 229–235; direction as a factor in, 237–240; efficient, 238–240; flexibility of, 239–240; role of inferences in, 236–237; place of language in, 240–241; motivation and, 235–236; as implicit trial and error, 235
Recall, 201–211; effect of emotion on, 219–220; of forms, 207–208; interpolated activities, 217–219; of narratives, 206–207; of paired associates, 205; as an aspect of reasoning, 198, 228; role of stimuli in, 210–211
Receptor field, 434
Receptor processes, 43–45, 385–488; role of in attending, 387–388; in perceiving, 400–401
Receptors, 43–45; auditory, 457–459; cutaneous, 478; development of in fetus, 79–80; evolution of, 43–45; gustatory, 476; kinesthetic, 482; olfactory, 471; organic, 486; static, 483; visual, 429–435
Receptor set, 385–388
Recessive gene, 96
Recitation, as a memory aid, 223; as a method of learning, 182–183; effect of on retention, 213, 223
Recognition, as social factor in learning, 176–177
Recognition memory, 204–205, 211
Redintegration, 210
Reduced cues, 210–211
Re-education, 374
Reflex arc, 48, 55; development of in fetus, 77–78
Reflexes, growth of fetal, 81–83; relation of to motives, 257, 272–274; in newborn, 84
Refraction, 420
Refractory period, 52
Regression, 315–317
Reinforcement, 123, 186–187; 190–191; negative, 187; primary; 186; secondary, 186
Reissner's membrane, 458
Relative movement, 441
Relative refractory period, 52
Relearning, 201
Reliability, of difference, 499; of mean, 498; of tests, 500
Remembering (*see* Memory)
Reminiscence, 216–217
Repetition, resistance to, 181
Repressing, 317–318
Reproducing a motor performance, 200–201
Reproduction of forms, 207–208
Reproof, as factor in learning, 174–175
Research, 25–38
Resistance to repetition, 181
Resonance, 452–453
Respiratory changes, emotional, 345–347, 371
Response learning, 184–191
Responses, nature of psychological, 20, 29–30
Restriction, effect on development, 105–110
Retardation, mental, 520–521
Retention, 197–224; distributed learning and, 212–213; effect of interpolated activity upon, 217–219; and original learning, 211–214; effect of recitation on, 213; and speed of learning, 213–214
Retina, evolution of, 44; structure of, 429, 431, 434
Retinal color mixture, 423–426
Retinal color zones, 427–428
Retinal disparity, 351–353
Retinal image, 429, 436
Retinal interaction, 435
Retroactive inhibition, 219
Reverberating circuits, 57–62
Reverie, 228
Revolving drum, 265
Rewards, in instrumental conditioning, 121–122; in learning, 172–177
Reversible configurations, 394
Rho (ρ), 503
Rhythm, as memory aid, 222; perception of, 563
Rivalry, as motivator of learning, 176–177
Rods, 430–433, 435
Root's introversion-extraversion test, 575
Rorschach test, 580–581
Round window, 457–458
Ruffinian cylinders, 478–479

Saccule, 483–484
Salivary response, conditioning of, 118–119
Saturation, color, 419, 423
Satyriasis, 267
Savings method, 201
Scattergram, 501–502
Science, meaning of, 8–9
Schizophrenia, 244, 600–601
Sclerotic coat, 429–430
Seasickness, 485–486
Seashore tests of musical talent, 562–563
Second order conditioning, 129
Secondary reinforcement, 186
Seizures (audiogenic), 319
Self-assertion, 287–289
Self-consciousness, 251
Self, 590
Self-excitation, 57–58
Self-repudiation, 312, 600
Selves, concept of, 590
Semicircular canals, 483–486
Semi-permeable membrane, 53
Senile psychosis, 598–599
Sensation, 384 (*see also* Receptor processes and Sensitivity)
Sense organs (*see* Receptors)
Sensitivity, auditory, 65, 447–467; as revealed by conditioning, 128, 131; cutaneous, 476–482; evolution of, 44–45; fetal, 79–80; gustatory, 475–476; kinesthetic, 482–483; in newborn, 83; olfactory, 470–475; organic, 486; somaesthetic, 64, 476–482; static, 483–486; visual, 64–65, 418–445
Sensory habits, 172 (*see also* Discrimination)
Sensory neuron, 46
Sensory contributions to learning, 168–169
Sensory projection areas, 60, 435

Sequential growth, 82, 98–99
Set, attending as an example of, 385–386; role of in perceiving, 411–412; control of in research, 33–34; role of in thinking, 237–240
Sex, as emotion, 350; as motivation, 265–267, 272
Sex determination, 92
Shadows, role of in perception, 441–442
Shock treatments, 601
Siamese twins, 94, 98
Sigma (σ), 497
Similarity factor in retroactive inhibition, 219
Simultaneous contrast, 429
Singerman color mixture apparatus, 425
Size, as a depth cue, 439–440; constancy, 408
Skeletal muscles, 354
Skewness, 495
Skill, acquisition of, 135–165; complex motor, 148–150; as factor in emotional control, 376; industrial, 149–150; manual, 45; motor and verbal compared, 135; transfer of, 156–163; verbal, 150–152
Skin senses, 63–64, 476–482
Sleep, E.E.G. in, 60, 62; as memory aid, 217, 223; effect of on forgetting, 217
Slips of the tongue, 297
Smell, 470–475; in food selection, 264
"Smell brain," 49
Smoking, 33–34
Social behavior, origins of in child, 82, 591; psychological investigations of, 18–19
Social conditioning, 285–289
Social environment, 19 (*see also* Social heritage)
Social heritage, 92, 116, 285–289
Social intelligence, 573–574
Social interaction, origins of, 82, 591
Social motives, 176–177
Social psychology, 18–19
Socialization, 285–289
Somaesthetic area, 63
Somaesthetic sensitivity, 63–64 (*see also* Cutaneous and Kinesthetic sensitivity)
Somatotonia, 588
Somatotypes, 586–589
Soul, 1, 3–5
Sound waves, 447–448
Sour-grapes reaction, 315
Space perception, auditory, 463–466; cutaneous, 480–482; visual, 436–443
Spatial maze defined, 233
Specific hungers, 263
Specific nerve energy (doctrine of), 51–52
Specificity of behavior, conditioned, 128; development of, 84
Spectrum, 420
Speech, role of brain in, 67–68; in chimpanzee, 105; role of conditioning in development of, 129–130; development of in child, 87–88, 150–151; evolution of, 45; subvocal, 240–241; role of in voluntary movement, 322
Speed of learning and retention, 213–214
Sphygmomanometer, 346, 371
Spinal cord, 48, 54–56, 77–78
Spontaneous movement, 81
Spontaneous recovery, 128
Standard deviation (σ), 497–498
Standard error of mean, 498; of a difference, 499
Stanford-Binet test, 512–516, 520–525
Startle-pattern, 343–344
Static sense, 483–486
Statistical analysis, 36–37, 493–506
Stereophonic effects, 467
Stereoscope, 438–440
Stereotyped behavior, 49–50, 277–279
Stimuli, defined, 28, 43; differentiation of, 128; role of in recall, 210–211
Stimulus, meaning of, 43; external, 28; internal, 28
Stimulus generalization, 126–123
Striatum, 60
Strong Vocational Interest Blank, 551
Structural disorders, 14, 598–599
Stylus mazes, 145
Subject, in psychology, 29–30
Subjective, meaning of, 20
Substitution learning, 151–152
Subtractive color, mixtures, 426
Subvocal speech, 240–241
Successive contrast, 428
Summation tones, 455
Surface colors, 419
Surface traits, 571, 582
Suspensory ligaments, 429–430
Symbolic processes, 202 (*see* Thinking)
Sympathetic nervous system, 55, 351–352
Synapse, 46
Synaptic nervous system, 46–47
Syphilis, behavior disorders and, 483, 598–599
Syringomyelia, 479

Tabes dorsalis, 483
Tabula rasa, 17
Tactual localization, 480–482
Tactual sensitivity, 63, 476–482
Tambour-mounted cage, 261
Taphephobia, 376
Taste, 475–476; in food selection, 264
Taste buds, 475–476
Tectorial membrane, 458
Telegraphy, learning curves for, 155–156
Temperament, 586–589
Temperature in motivation, 269
Temperature senses, 477–479
Temporal lobe, 59
Temporal maze, 233
Tension, 305
Tensor tympani, 457
Testimony, accuracy of, 208–209
Testosterone, 266
Tests, aptitude, 551–562; group, 531–541; infant, 510–512; performance, 528–531; personality, 572–582; projective, 580–582; standardization of, 513–516, 557–562; Stanford-Binet, 512–516, 520–525; verbal compared with performance, 528–529
Thalamic (hypothalamic) theory, 355
Thalamus, 56–57, 60, 355
Thematic apperception test, 582
Theories of learning, 184–191
Therapy, 579–580, 601
Thinking, 197–198, 228–253; and the brain, 249–251; creative, 246–249; E.E.G.'s during, 60, 62
Thirst, 267–268, 272
Thought processes, 228–253
Threshold, 413–414
Thwarting (*see* Frustration)
Thyroid gland, 584–586
Timbre, 451–453
Tobacco, experiment on effects of, 33–34
Tolman's theory, 184–191
Tone, compared with noise, 448–449
Tongue, receptors of illustrated, 476
Tonic immobility, 217
Tools, evolution of, 45; use of by animals, 141–144
Topology, 307, 584
Training, compared with practice, 150
Traits, 571
Transfer, 156–165; bases of, 160–162; bilateral, 156–157; negative, 162–163; pencil-and-paper to motor task, 157–158; positive, 156–162; from verbal activities, 157–162
Transmission curve, 421
Trial and error, in cafeteria feeding, 264; in creative thinking, 248; defined, 138; implicit, 146–147; overt, 198; as reaction to conflict, 309; as reaction to danger, 378
Tridimensional vision, 438–441
Tropism (tropistic behavior), 257
Trot reflex, 81–82
Tweezer dexterity test, 558
Twins, identical and fraternal, 94, 110; intelligence of identical, 100; origin of, 94
Two-hand co-ordination test, 175–176
Two-point threshold, 481–482
Tympanic canal, 458
Tympanic membrane, 457
Typewriting, habit hierachy in, 152

Ulcers, peptic, 373–374
Ultraviolet light, 418–419
Unconditioned response, 117; relation of conditioned response to, 123–124
Unconditioned stimulus, 117
Unconscious motivation, 294–295
Utricle, 483

Valences, 307

Validation procedures, 559
Validity, 500
Values, as aspects of personality, 574–575
Variables, 29–30
Variability, measures of, 496–499
Vascular theory, 479
Vectors, 307
Ventral columns of cord, 55
Ventral root, 55
Verbal behavior, 20
Verbal skills, acquisition of, 86–88, 150–152, 197–223; transfer of, 157–162 (*see also* Memory)
Verbalization, as a factor in skill, 135–136, 149
Verification stage in creative thinking, 248–249
Vestibule, 483
Vestibular canal, 458
Vicarious functioning, 65, 67–68
Viscera, 54–55, 354–355
Visceral afferent fibers, 54–55
Visceral reactions in emotion, 345, 354–356; in organic sensitivity, 486
Viscerotonia, 588
Visible spectrum, 420–421
Vision, 418–445; and cerebral cortex, 64–65, 435; role of in learning, 168–169; physical concomitants of, 418–429; structural bases of, 429–436; tridimensional, 436–443
Visual accommodation, 430
Visual acuity, 433–434
Visual purple, 432–433
Visual stimulation, 418–423
Vitamin A and night blindness, 433
Vitreus humor, 429–430
Vocalization, 86–87, 105
Vocality, 447
Vocational guidance, 563–564
Vocational Interest Blank, 551
Vocational selection, 563–564
Voice in emotion, 344–345
Volley theory, 461–463
Volume, 447
Voluntary attending, 394
Voluntary movement, 65–66
Voluntary control, development of, 322

Wakefulness, 57
Walking (*see* Locomotion)
Warm spots, 477
Wave length, 422
Waxy flexibility, 600
Weber's law, 413–414
Wechsler-Bellevue test, 517–518, 531
Wever-Bray effect, 459–460
Whirling, inheritance of, 96–97
White-black continuum, 422
White light, 420
White matter, 54
Whole vs. part learning, 183–184, 223
Wiggly block, 154
"Will power," 319–322
Will to learn, 220–221
Will to power, 319–322
Withdrawal conditioned, 119–120, 124
Word blindness, 67
Word deafness, 67
Worry, 377
Writing, development of, 88

X and Y chromosomes, 92

Young-Helmholtz theory, 431–432

Zöllner illusion, 405
Zuñi Indians, 287–289

PSYCHOLOGY

by NORMAN L. MUNN

The answer to the most puzzling of all questions—what is Man?—is here seen from the viewpoint of modern psychology. Dr Munn analyses, with a brilliant simplicity of method, the components of that vastly complex creature, and his book thus meets the needs of those who desire an integration and selection of all available knowledge on the subject of man's psychology. Moreover, the book is masterfully planned so that the greatest possible lucidity may be achieved. For example, names of authors and sources of quotations are not allowed to confuse the text but are arranged systematically and accessibly in the index.

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